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Explanatory Note

Illustrated articles are marked with an asterisk (*), book notices by a dagger (†), inquiries by a double dagger (‡). The cross-references condense the matter and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Smoke," and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross-reference. A reference from "Oil" to "Lubricant" would apply equally to "Lubrication," "Lubricator," etc. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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POWER

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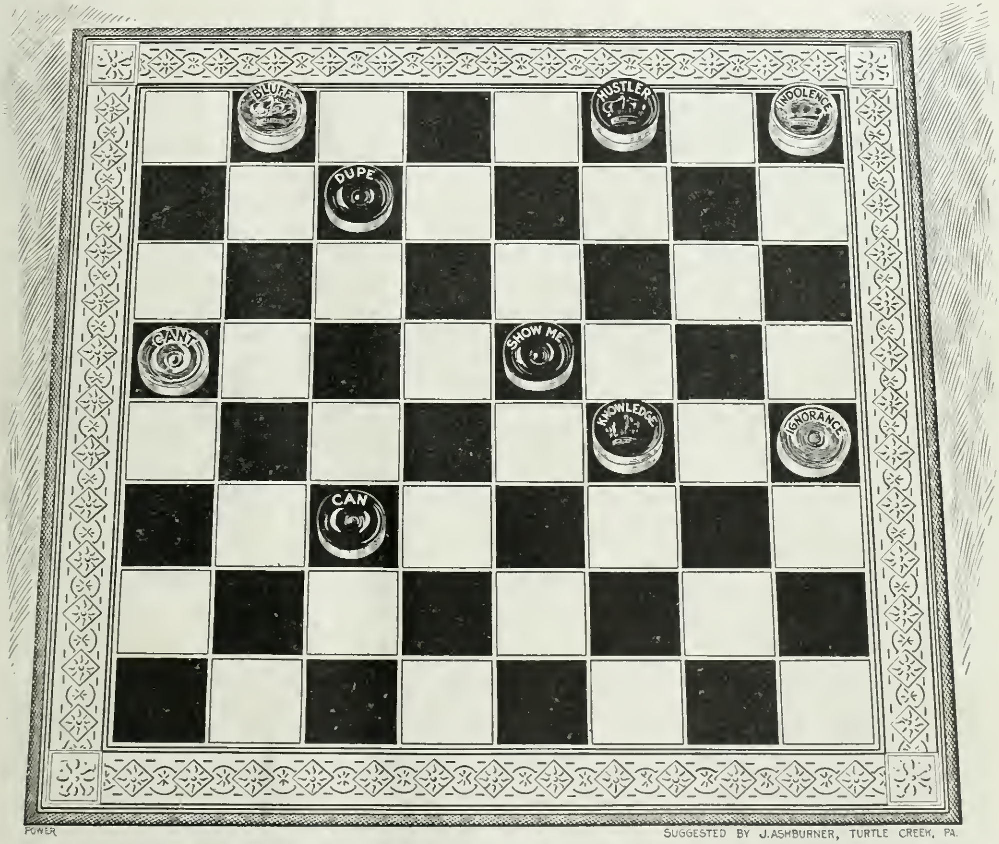


POWER SUGGESTED BY J.ASHBURNER, TURTLE CREEK, PA.

Playing the Game

DID you ever play a game of checkers? If so, you can see the points intended to be brought out in the cartoon. Every engineer is playing a game every day of his life. If he knows his job he can corner the other fellow every time. Examine the board and see what characteristics win out. King Bluff is in his own king row. He is in a position to jump the misled superintendent, or Man Dupe, and it is King Bluff's move. He jumps Man Dupe and gets in the way of Man Show me, and is immediately put out of business.

King Indolence has also got into his own king row and it is his move. When he does move King Hustler puts him out of the game. Man Can't is cornered by Man Can and Man Ignorance is sewed up tight by King Knowledge.

Moral: The best man always wins.

Staley Power Plant in Decatur

By Thomas Wilson

SYNOPSIS—This boiler plant is producing steam for 10.6c. per 1000 lb. A change from manual to automatic operation in handling the coal and ashes has reduced the boiler-room labor bill two-thirds, saving $43 per day.

⁂

In Decatur, Ill., the A. E. Staley Manufacturing Co. has a large plant for making starch of all varieties and other byproducts of corn. At the present rate of working, a maximum of about 800 kw. for power and lighting is required. There is a total of 90,000 lin.ft. of 1-in. pipe which must be supplied with exhaust and live steam to heat 300,000 cu.ft. of air per min. blown over the starch to dry it. Besides, steam for industrial purposes is in considerable demand; in fact, the load on the boilers is about equally divided between the engine room and the manufacturing plant.

The Boiler Plant

To supply this steam, four 550-hp. water-tube boilers have been installed, and, although only three, under damper control, are required to carry the load at present, it is expected that the demand for steam will increase sufficiently to warrant the two more boilers of the same size which will soon be installed.

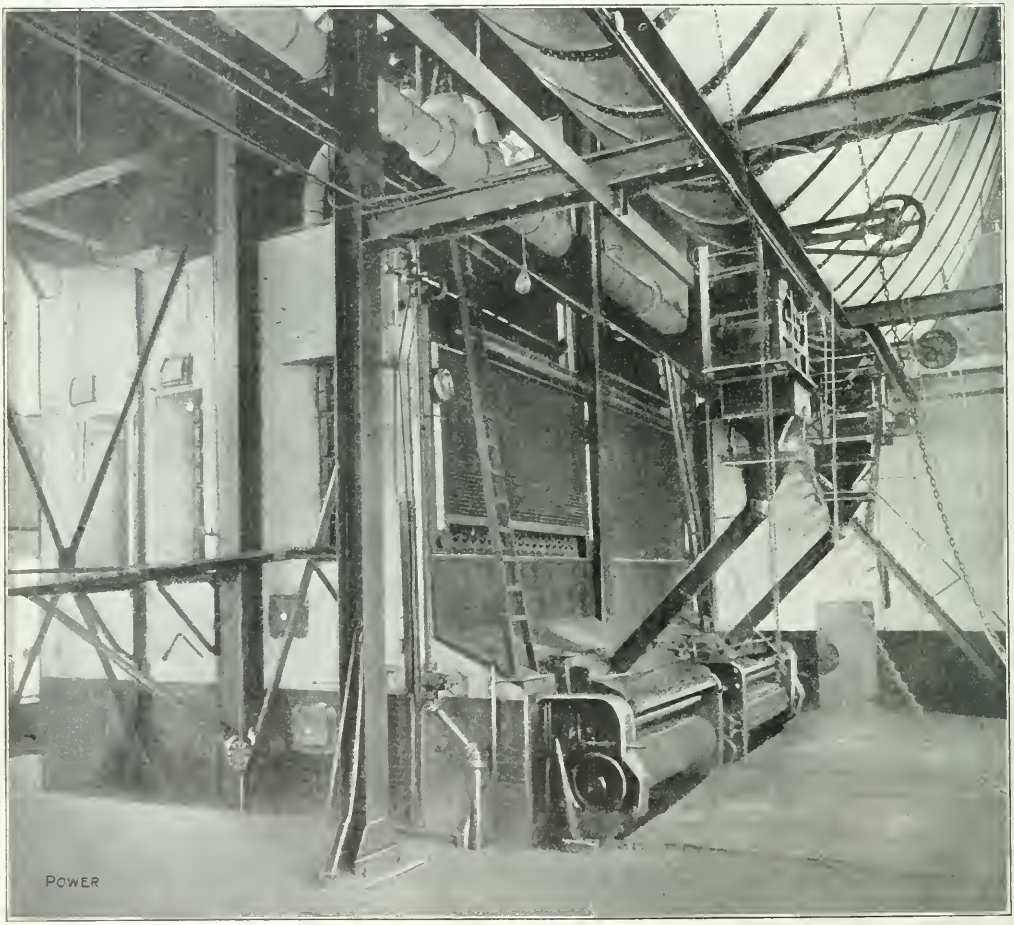


Fig. 1. Two of the Boiler Units, Showing Bunker and Coal Scales

Each boiler has 5500 sq.ft. of heating surface and is equipped with a chain-grate stoker having 100 sq.ft. of effective grate area. The ratio of heating to grate surface is 55 to 1, and may be counted low when it is considered that the settings have been designed for normal loads of 200 per cent. of the builders' rating of the boilers. The air surface in the grates amounts to 35 per cent. and, because of the diagonal slots in the sides of the link, which are reversed in direction in the opposing link, this proportion is maintained without allowing a large percentage of the fine coal to drop through to the ashpit.

FURNACE DESIGN

As will be apparent in Fig. 2, giving a sectional view of one of the boilers, the furnace and setting have special features worthy of attention. The long ignition arch, together with the corbeling forward of the bridge-wall, results in a contracted opening through which the gases must pass at right angles to their previous flow, the intention being to produce the sudden and thorough mixing necessary for the best combustion. The bottom of the tube header is 9 ft. 6 in. above the boiler-room floor and the stoker is set well under the boiler, so that there is little furnace extension. This arrangement gives a combustion space formed by a horizontal chamber underneath the long arch and a vertical chamber immediately under the first pass of the boiler; therefore, it is claimed that a strong igniting effect is secured near the feed gate where the fuel is first introduced to the furnace. As a consequence, the entire fuel bed is active and ready to respond to any increase in draft over the fire. In this particular plant there are frequent calls for large quantities of steam, and it was this condition which influenced the design of the furnace to a great extent.

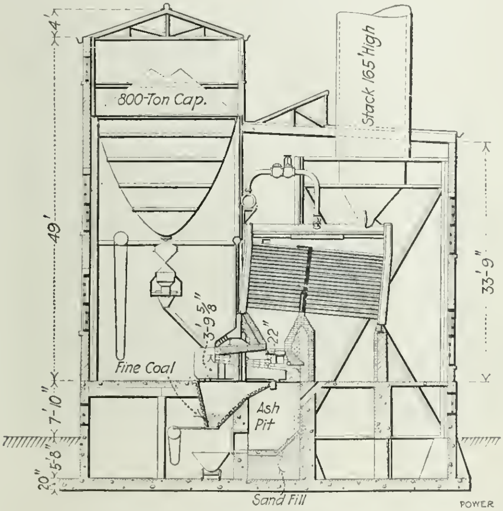


FIG. 2. SECTIONAL VIEW OF ONE OF THE BOILERS

At the rear end of the grate, underneath the opening between the arch and the bridge-wall, the combustion is intense, due to the draft available at this point, the thorough mixing of the gases and the strong ignition previously referred to. This capacity to meet sudden fluctuations in load and at the same time maintain the fires in uniform condition is in part responsible for the excellent records given on the next page.

DRAFT

The boilers are of the three-pass type, arranged two per battery, each pair having a common steel stack rising 200 ft. above the grates. This stack is 10 ft. in diameter and has a 6-in. lining of four-cell, radial tile which reduces the bore to 9 ft. The draft on the stack side of the damper is 1.3 in. of water, and over the fire is maintained by the damper at 0.4 to 0.6 in., although it can be run up to 1 in. if required.

The uptake at the boilers is rectangular, measuring 11 ft. 5½ in. by 2 ft. 4 in., and gradually rounds to the internal diameter of the stack. There is but little obstruction to the flow of gases. In a sense, there is no breeching. The flow of the gases from the boiler is upward directly into the stack. Two right-angle turns are avoided, also the interference of the gases of one boiler with those of another, and the friction of a long run of breeching. To secure these benefits, three stacks instead of one are necessary, but it was considered that the additional cost was warranted as it gave a natural-draft plant with nearly as great a range as would ordinarily be obtained with a forced-draft outfit.

FINE-COAL HOPPER

Another feature, shown in Figs. 2 and 3, is the fine-coal hopper under each stoker, arranged so that it will

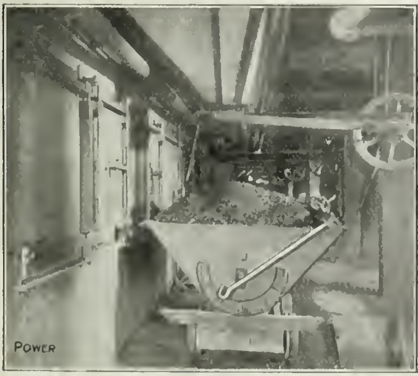


FIG. 3. ASH CARS AND FINE-COAL HOPPER ABOVE

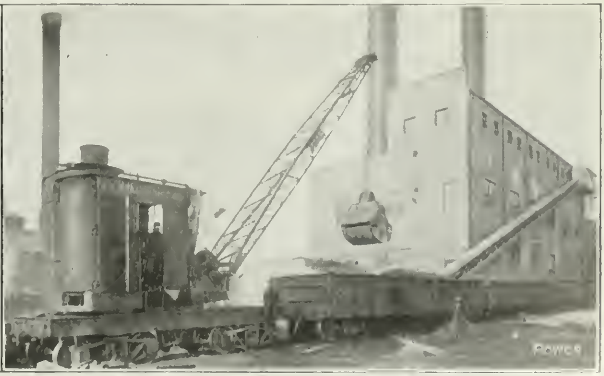


FIG. 4. LOCOMOTIVE CRANE AND INCLINED BELT CONVEYOR AT SIDE OF BOILER ROOM

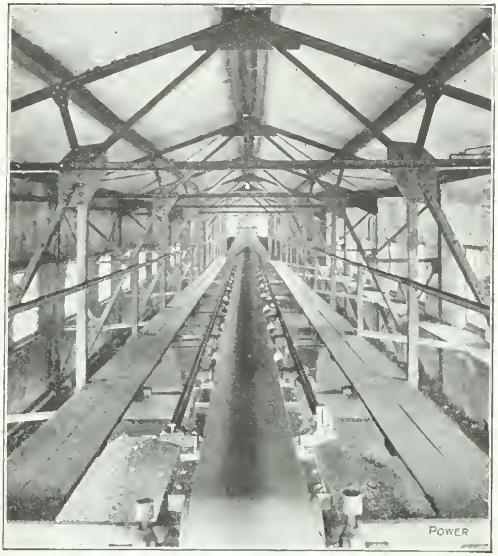


Fig. 5. Conveying Belt over Bunker

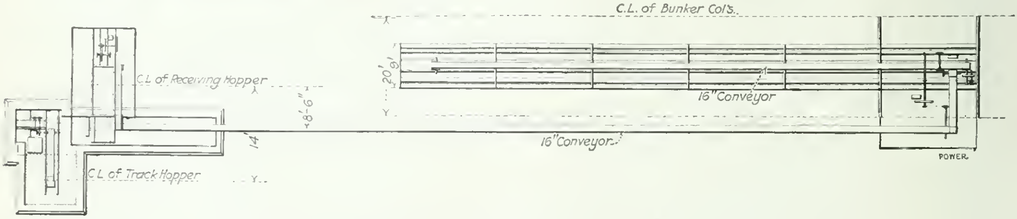


Fig. 6. General Arrangement of the Conveyor System

TABLE 1. COST OF STEAM AT THE STALEY PLANT

	Monday Feb. 9, 1914 Day	 Night	Tuesday Feb. 10, 1914 Day	 Night	Wednesday Feb. 11, 1914 Day	 Night	Thursday Feb. 12, 1914 Day	 Night	Friday Feb. 13, 1914 Day	 Night	Saturday Feb. 14, 1914 Day	 Night
Duration of run, hr. ..	11	13	11	13	11	13	11	13	11	13	11	13
Boiler pressure, lb. gage	142	142	142	142	142	142	142	142	142	142	142	142
Feed-water temp., deg. F	200	200	200	200	200	200	200	200	200	200	200	200
Evaporation factor. . .	1 057	1.057	1 057	1.057	1 057	1 057	1.057	1 057	1 057	1.057	1.057	1 057
Total water evaporated, lb.	1,071,204	1,198,296	935,034	1,161,984	1,008,580	1,098,438	1,034,892	1,181,957	1,080,282	1,229,161	925,056	1,014,920
Total equiv evap. f. and a. 212 deg. F.......	1,132,262	1,266,598	988,331	1,228,217	1,066,069	1,161,058	1,093,880	1,249,328	1,141,858	1,299,223	977,784	1,072,770
Water evap. f. and a. 212 deg. per hr.	102,933	97,431	89,849	94,478	96,915	89,312	99,443	96,102	103,805	99,940	88,889	82,521
Evap. f. and a. 212 deg. per lb. coal as fired, lb... ..	8.09	7.63	6 59	7.22	7.5	7	7.6	7.1	8.27	8.02	6.88	6.62
Boiler hp. developed. ..	2983	2824	2602	2738	2809	2588	2882	2786	3008	2897	25.77	2390
Per cent. of builders rated hp.	181	171	158	166	170	157	175	169	182	176	156	145
Weight of coal as fired, tons	70	83	75	85	71	85	72	88	69	81	71	81
Grate surface in use, sq.ft.	300	300	300	300	300	300	300	300	300	300	300	300
Coal burned per sq.ft. of grate per hr., lb.........	42.4	42.5	45.4	43.6	43	43.6	43.6	45 2	41.8	41.5	43	41.5
Cost of coal, dollars.......	98	116.20	105	119	99.40	119	100.80	123.20	96.60	113.40	99.40	113.40
Cost of fireman, assistant, 4 laborers, dollars... ..	21.20	17.65	20.20	20.05	22.02	24.30	20.85	21.42	21.52	19.70	22.02	20.05
Total fuel and labor cost, dollars	119.20	133.85	125.20	139.05	121.42	143.30	121.65	144 62	118.12	133.10	121.42	133.45
Cost of 1000 lb. steam f. and a. 212 deg. F., dollars	0.106	0.106	0.127	0.113	0.113	0.123	0.111	0 116	0 103	0.103	0.124	0.125

deliver the coal to the same cars which receive the ashes: the coal is returned to the conveyor system. The ash cars are of steel and side-tilting: the car body is detachable so that it can be picked up by a crane and the contents dumped into a railway car. The ash hopper is reinforced concrete. The doors are lined with firebrick, mounted on rollers, and, as may be seen in Fig. 3, are specially equipped with a system of levers by which they can be made air-tight. Leakage of cold air around the rear of the grate is not conducive to good combustion or operation at high capacity; hence the desirability of excluding the air.

Producing Steam for 10.6c. per 1000 Lb.

Unwashed Springfield screenings, $1\frac{1}{4}$ in., is the fuel used, and in average daily operation from 42 to 45 lb. are burned per square foot of grate. This rate of combustion is obtained with a draft of 0.4 to 0.6 in. over the fire, carrying a 9-in. fuel bed, and if the maximum draft which the stack could produce were used, the rate would be still higher. Per pound of coal as fired, the evaporation from and at 212 deg. F. ranges between 7 and 8 lb., but it must be remembered that this is obtained with dirty coal, not exceeding 10,000 B.t.u., which costs $1.40 per ton delivered to the bunkers.

The data given in Table 1 for the week of Feb. 9 to 14 show what the plant is doing. No attempt was made to select favorable data; a week's record was picked out at random, so that the results should represent the average performance. It will be noticed that three boilers were run at 145 to 181 per cent. of the builder's rating 24 hr. per day. The cost for coal and labor per thousand pounds of steam runs as low as 10.6c. When it is considered that the usual cost for the same output averages from 15 to 20c., it will be appreciated that remarkable results are being obtained. When the plant is extended and the load increased so that the boilers may be run at fully 200 per cent. of rating without any appreciable increase in labor, the above costs may be slightly lowered.

Burning the lowest-priced coal on the Decatur market under excellent conditions for good combustion, and an efficient coal-handling system reducing the labor in the boiler room to a minimum, are the factors responsible for the low cost of steam.

To be consistent, a conveying belt system transfers the coal in the railway car to the stokers at a cost ranging from 2 to 3c. per ton. The system has a capacity of 50 tons per hour, a bunker storage of 800 tons and between the bunker and hopper of each stoker a Richardson scale intervenes, so that the weight of fuel to the furnaces may be recorded as it is used. A 10-hp. motor moving 680 ft. of belt is the power required for transferring the coal. The general arrangement of the system is shown in Fig. 6. Fine coal is discharged from bottom-dump cars into a 10x10-ft. track hopper to the bottom of which are attached skirt boards for guiding the coal onto a short cross-belt delivering to a 16-in. inclined belt running along the side of the boiler room, as in Fig. 4. At the point of feed, a slide gate is provided which may be regulated from the ground level. Run-of-mine coal is discharged into a 12x12-ft. receiving hopper by a locomotive crane which also handles the coal to and from the outside storage. From the hopper the coal passes to a shaking feeder given a reciprocating motion by a pair of connecting rods through crank disks and a direct gear drive to a 3-hp. motor. The shaker feeds the coal to a two-roll crusher (rolls, 20 in. in diameter, with 30-in. face) at a uniform rate of 50 tons an hour. From the crusher, which is driven by a 20-hp. motor, the coal is delivered to the inclined conveyor. A bypass chute around the crusher handles the fine coal.

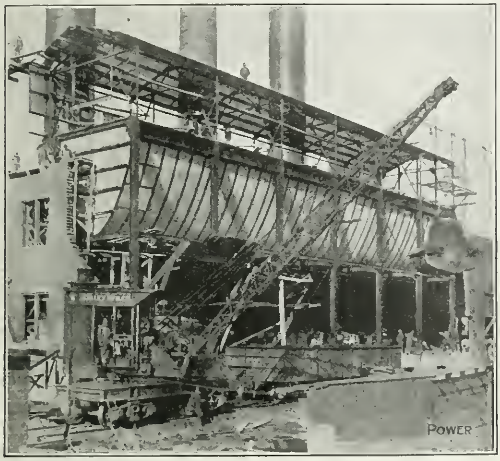


Fig. 7. Ferro-Inclave Bunker under Erection

All of the conveyors are designed for a speed of 250 ft. per min. From the receiving hoppers to the upper end of the incline is approximately 184 ft., and the rise about 40 ft. above the ground level. A short cross belt transfers the coal to the delivery belt running over the bunker in a reverse direction and parallel to the inclined belt. The conveyor over the bunker has an automatic self-reversing-and-propelling tripper with 90 ft. of track; this appears in the background of Fig. 5. An elevator at the near end of the boiler room would have shortened the coal travel, but it would have necessitated more power per ton of coal delivered. As it is, a 10-hp. motor, by means of the transmission mechanism indicated in Fig. 6, drives the four conveyor belts.

Fig. 7 shows the coal bunker under erection. This is made of steel and concreted on both sides; the method of support is indicated. The shape of the bunker insures delivery of most of the coal to the hoppers of the automatic scales, which weigh 100 lb. at a time. The scales are mounted on a structural-steel carriage carried by wheels on a channel iron runway. A motor operates the shaking feeder of the scale, and the gates admitting the coal from the bunker are controlled by a chain reaching to the floor.

Saving $43 per Day in Labor

Before the new boiler plant was installed, the company had in its plant three 235-hp. and one 280-hp. water-tube boilers equipped with shaking grates. The coal was unloaded and fired by hand and the firemen were worked on three 8-hr. shifts. Thirty-seven men were employed at a cost of $63.60 per day of 24 hr.

When the new plant was installed and equipped with stokers and the coal- and ash-handling systems, the number of men was reduced to 10, the time to two 12-hr. shifts and the cost of unloading the coal from 6 to 7c. per ton to a figure averaging from 2 to 3c. The number of men, the duties of each and their wage are given in Table 2.

The Engine Room

In the engine room, Fig. 8, part of the old equipment is still retained. This consists principally of a 550-kw. generator driven through a rope by a 24x42-in. Corliss engine, a 1000-kw., single-stage, noncondensing turbo-unit and a 100-kw., direct-connected engine-driven unit. Each generates three-phase current at 440 volts, used direct by the motors and transformed to 110 for lighting.

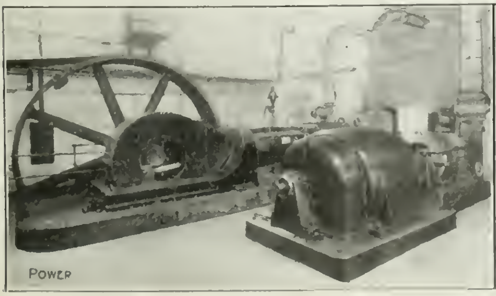


Fig. 8. Turbine and Corliss Engine Units

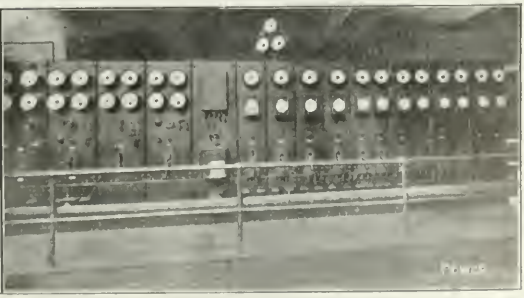


Fig. 9. View of the New Switchboard

The initial steam pressure to these machines averages 150 lb. gage and the back pressure 2½ lb. A steam-flow meter has just been installed to measure the steam to the engine room, and it is intended to have others, so that each department may be credited with its proper consumption.

TABLE 2. LABOR DISTRIBUTION IN BOILER ROOM

Old Method	
3 Firemen, three 8-hr. shifts at 25c.	$18 00
2 Fire pullers, three 8-hr. shifts at 25c	12 00
2 Coal passers, two 12-hr. shifts at 17½c.	8 40
4 Unloading coal, three 8-hr. shifts at 17½c.	16 80
2 Ash wheelers, three 8-hr. shifts at 17½c.	8 40
	$63 60
Average cost of unloading coal per ton (including unloaders and coal passers)	$0 06 to 0 07
New Method	
1 Fireman, two 12-hr. shifts at 20c.	$4 80
1 Helper, two 12-hr. shifts at 17½c.	4 20
2 Ashmen, two 12-hr. shifts at 17½c.	8 40
2 Men unloading coal 10-hr. at 17½c	3 50
Total	$20.90
Average cost of handling coal per ton	$0 02 to 0.03

A Model Switchboard

On the electrical end the same plan has already been adopted. There is a meter for every department. The switchboard, Fig. 9, is the feature of the engine room and gives some indication of what this part of the power plant will be when completely remodeled. Both the board and the instruments have been painted black, and with bright metal trimmings the appearance is neat and attractive. There is a full assortment of Westinghouse instruments. Midway between the back of the board and the wall are the hand-operated oil switches. The operating levers and the cables run under the floor and up through pipes to the switches; the outgoing cables are also run under the floor to the wall and are inclosed in pipes. Thus the space back of the board is unusually clear and, contrary to usual practice, presents an orderly appearance

An innovation in switchboard lighting has been introduced. A row of incandescent footlights, mounted in a long reflector secured to the railing, shine upward on the instruments, and a similar row shine down from a canopy over the board. With this arrangement there is no shadow on the face of the meters, and a reading may be taken accurately from any position.

To G. E. Chamberlain, superintendent of the company, belongs the credit for the layout of the new power plant and for many labor-saving devices in manufacturing the different products.

TABLE 3. PRINCIPAL EQUIPMENT OF STALEY POWER PLANT, DECATUR, ILL.

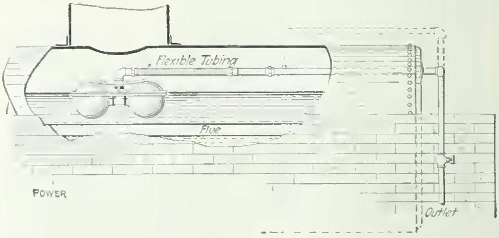
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	550 hp.	Steam generators	150 lb. gage, mechanical stokers.	Edge Moor Iron Co.
4	Stokers.	Chain grate.	100 sq.ft.	Boiler furnace	Mechanical	Laclede-Christy Clay Prod. Co.
2	Stacks	Steel, 6-in. lining	200x10 ft	Furnace gas	Draft stack 1 3 in., over fire 0 4 to 0 6 in.	Hammler, Boiler & Tank Co.
1	Bunker.	Ferroinclave.	800 tons.	Coal storage		Brown Hoisting Machinery Co.
1	Conveyor system	Belt	50 tons per hr	Coal car to bunker	250 ft. per min	Robins Conveying Belt Co.
4	Ash hoppers	Reinforced concrete		Ash from boiler furnace		Brown Hoisting Machinery Co.
1	Ash cars.	Steel side tilt		Ash from hopper to dump		Brown Hoisting Machinery Co.
1	Crane	Locomotive.	15 tons	Handling coal and ash	125 lb. gage	Brown Hoisting Machinery Co.
1	Feed water-heater.	Open.	3000 hp.		Exhaust steam	Harrison Safety Boiler Works
4	Scales	Automatic.	100 lb. per weighing	Coal for boilers	Weigh as coal is fed to stoker.	Richardson Scale Co.
2	Pumps.	Single	12x7x12 in.	Boiler feed.	150 lb. steam pressure	American Steam Pump Co.
4	Pumps	Duplex	8x8½x12 in.	Water mfg. purposes.	150 lb. steam pressure	Worthington Steam Pump Co.
1	Pump	Duplex	16x10x18	Boiler feed	150 lb. steam pressure.	Canton Hughes Pump Co.
1	Pump	Duplex	12x12x24	Mfg. purposes.	150 lb. steam pressure.	Wilson Snyder Mfg. Co.
1	Pump	Duplex	14x10x18	Mfg. purposes.	150 lb. steam pressure	Wilson Snyder Mfg. Co.
1	Engine	Corliss	24x42 in.	Rope to alternator	150 lb. initial 2½ lb. back pressure.	Vilter Mfg. Co.
1	Turbine	Impulse, four-stage	1250 kv.a.	Direct connected to alternator	150 lb., sat. steam, 3600 r.p.m.	Southwark Foundry & Mach. Co.
1	Engine.	High speed	13″x13″	Belted to alternator	150 lb. initial 2½ lb. back pressure	A L Ide & Sons
1	Rope drive	American	38 ft centers.	Corliss engine to alternator	14 strands, 1¾ in. rope 1740 ft. long	Dodge Mfg Co.
1	Generator	Alternating current	550 kv.a.	Main unit	Three-phase, 60-cycle, 440 volt	Allis-Chalmers Co.
1	Generator	Alternating current	1250 kv.a.	Main unit	Three-phase, 60-cycle, 440-volt, 3600 r.p.m	Crocker-Wheeler Co.
1	Generator.	Alternating current	100 kv.a.	Main unit	Three-phase, 60-cycle, 440 volt	Allis-Chalmers Co.
1	Generator.	Direct current	30 kw.	Exciter	Belted to 100 kv.a. engine, 125 volt.	General Electric Co.
1	Generator	Direct current	25 kw.	Exciter	Motor driven, 125 volt	Allis-Chalmers Co.
1	Motor	Induction	35 hp.	Driving exciter.	440 volt, 860 r.p.m.	Allis-Chalmers Co.

* * *

Schreiber Boiler Skimmer

A device known as the Schreiber boiler skimmer, for removing scum in steam boilers, is illustrated herewith. It can be placed in any type of boiler.

As shown, the skimmer consists of two copper seamless floats, around which, just above the center line, is a hollow band slotted on the outside. There are four copper discharge pipes secured to the upper side of the band at one end and to the main discharge pipe at the other. The main discharge pipe is flexible copper tubing, which allows the skimmer to rise and fall with the water level in the boiler.



Schreiber Boiler Skimmer

Owing to the shape of the skimmer, floating particles are drawn into the slot from all sides when the blowoff valve is opened. The outlet can be carried through the rear of the boiler or out through the top, as shown by the dotted lines. The skimmer is manufactured by the Lincoln Boiler Cleaner Co., Lincoln, Ill.

* * *

The Total Mechanical Power in the United States is estimated at 120,000,000 hp. This includes 19,400,000 hp. in manufacturing industries, 7,700,000 in central light and power stations, about 7,000,000 in isolated plants (exclusive of manufacturing), 3,400,000 in electric railways, 50,000,000 in steam locomotives, 4,000,000 in steamships, 22,500,000 in automobiles and the balance in miscellaneous services such as irrigation, mines, etc.

Draft and Draft Readings

By Osborn Monnett

SYNOPSIS—For smokeless operation with coals of high volatile content, induced or forced draft is not as satisfactory as natural draft. Disadvantages of underground breechings and how to take draft readings.

※

Induced Draft

There is no question but that induced-draft systems can be so operated as to produce smokeless conditions. In large plants where the fan system is steam driven and installed in duplicate, and where the attendance is first-class, good results can be obtained. An induced-draft system naturally goes with an economizer and such a combination is considered good practice. Economizers on natural draft, however, are of doubtful value, particularly where special brick settings are used to prevent smoke. In such cases the low draft in the furnace is liable to reduce the life of the brickwork and interfere seriously with the combustion.

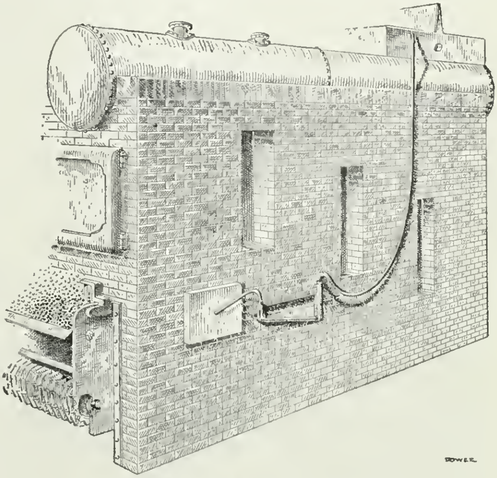
Frequently an attempt is made to increase the capacity of a small plant, where the stack is too small or too low, by installing a motor-driven, induced-draft outfit. This means another piece of equipment to get out of order, and with the frequent blowing of fuses, etc., the plant generally makes as much smoke as before. In the end, the furnace brickwork is usually melted down for lack of draft. Such makeshifts should be discouraged.

Induced draft for hand-fired plants does not work out well when the fan is controlled by the steam pressure. Due to the volatile matter distilling off and an insufficient supply of air, the plant will invariably smoke when the fan slows down. Attempts have been made to train men to fire when the fan speeds up and to cease firing before the steam pressure slows down the fan, so that at periods of low draft there will be a bed of coked coal in the furnace. Such attempts have been failures from a smoke standpoint; it is beyond the capacity of the average fireman to be so machine-like in regularity. An induced-draft outfit, hand-fired, might be clean if the throttle of the fan engine were brought down to the firing floor and manipulated by the fireman according to the condition of the fire. Even then it would be difficult to get a fireman who would operate the plant satisfactorily. As a matter of fact, automatic draft control, depending on the steam pressure, is almost certain to give smoke trouble where coal of 30 per cent. volatile content or higher is used.

In the case of mechanical stokers with induced draft, the control, if any, should be such that the stoker engines will slow down before the induced-draft fan and *vice versa;* otherwise, the fires will smoke. Induced-draft fans should always be steam driven. Motor-driven fans frequently become overloaded and blow fuses when the ashpit doors are closed. This causes the plant to smoke while repairs are being made. For smokeless operation there is nothing so safe and sure as natural draft.

Forced Draft

Forced draft has its legitimate field in connection with underfeed stokers and for the burning of anthracite coal. For hand-fired installations using high volatile coal forced draft is not conducive to smokeless operation. There is a peak demand for air immediately after firing to take care of the large amount of volatile matter being distilled off at this time. This air can be supplied at the right place and at the right time only by admission over the fire. With forced draft, while air enough is supplied to take care of the fixed carbon in the fuel, air cannot be admitted over the fire in sufficient quantity to burn the volatile matter, the tendency being to blow the gases out into the boiler room. For these reasons the forced-draft, hand-fired installation using high-volatile coals is usually a smoky plant.



Draft Gage and Connections

Four-Pass Boilers and Underground Breechings

Either of these arrangements call for extra investment in stack to overcome the greater resistance of the setting, and it is doubtful if any net gain results. The underground breeching has disadvantages peculiar to itself. It is out of sight and out of mind, and always imposes more work on the stack. It is difficult to clean without shutting down the plant, and unless the construction is exceptionally thorough it frequently fills up with water.

As usually arranged, the fourth pass has not even the excuse of affording the gases contact with the heating surface and consequently should be avoided. In like manner, passing the gases over the top of the shell in horizontal return-tubular boilers is ill advised, when considered from the overall standpoint. With natural draft such settings are more than liable to cause smoke if capacities much over the boiler maker's rating are attempted. If they have any legitimate field at all, it is in connection with well designed, induced-draft installations, or with underfeed stokers.

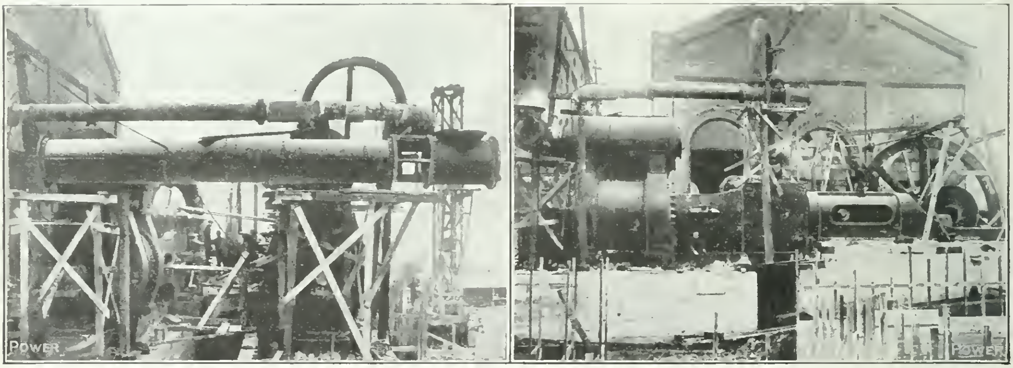
Taking Draft Readings

In taking draft readings on boiler plants the old U-tube should be discarded as it is not accurate. A differential-draft gage should be used, graduated in hundredths of an inch. The draft over the fire should be taken when the fires are clean and bright shortly after they have been charged with coal, and while the load is normal. A fictitious reading may be obtained where the draft is poor from crowding the furnace with a heavy fire.

In taking the drop through a run of breeching or through a boiler setting, two connections should be made to the draft gage, as indicated in the illustration. The gage then gives an instantaneous reading between the two points and the result is more reliable than a direct reading at each point, as conditions may change between the two readings. The illustration shows how a differential reading is taken to indicate the loss of draft through a boiler setting.

Rapid Erection of a Large Blowing Engine

The Mar. 24 issue described two 900,000-lb. blowing engines, which were built by the Mesta Machine Co., Pittsburgh, Penn., for the Woodward Iron Co. As stated, the high-pressure steam cylinders were 48 in. in diameter and the low-pressure steam cylinders were 84 in. in diameter, with 84-in. air cylinders and 60-in. stroke. The first engine was built in 38 days and both were completed in 59 days. Probably this was the world's record in building large engines and the erection of the same is thought to be the record for the type.



Two Views of the Large Blowing Engine during Erection at the Plant of the Woodward Iron Co., Woodward, Ala.

On Tuesday, Dec. 23, word was sent that the first engine was being shipped from Pittsburgh. The Woodward Iron Co., although anxious to start its new furnace, had done nothing to prepare a foundation, as it was expected that a much longer time would be required to complete the engines; consequently, the ground was covered by a large cinder pile. However, on receipt of the message, work on the foundation was started. By the following Monday evening it was completed and the first casting was in position.

As no overhead cranes were available, it was necessary to resort to makeshift methods in assembling the engines speedily. A railroad track was laid alongside and at each end of the foundation, and a 25-ton railroad crane with an arm of 40-ft. radius procured. The crane was also used for various duties, including repairs about the plant, so that at times the erectors would be deprived of its use for a whole day; therefore, they had to utilize other methods. As an illustration of the difficulties encountered, to get from one end to the other of the foundation, a distance of a few yards, the crane had to travel two miles.

To place the extra-heavy pieces, a skidway built of heavy rails was improvised from the car to the foundation. The heavy castings were then skidded into position above the foundation and lowered by jacks.

To facilitate the erection of the air lines to the furnace, the air cylinders and receivers were placed in position as soon as possible. After this was done, however, it was impossible to use the yard-crane as before, because of the interference with the receiver. An old crane with a useless boiler was then pressed into service and connected to a live-steam line. A cable-way was strung from this to the other crane, at the opposite end of the foundation; in this way it was possible to handle the valves and other engine parts without striking the top of the receivers. When the pistons were ready to be placed it was impossible to get close enough to use the cranes. The pistons were, therefore, put on blocks and rolled into position.

When the first engine was started the steam pressure available was only 60 lb. Before starting the second, however, some of the old engines were shut down and by further changes the steam pressure was raised to 120 lb. The first engine, operating at 60 r.p.m., is used for blowing a new 500-ton furnace. Immediately after starting, it ran for seven days continuously and then was shut down a couple of hours for small adjustments.

The foundation for the second engine could not be started until all the heavy parts of the first engine had been erected, since the tracks were laid over the ground for the foundation.

Erecting the second engine was as difficult as the first, and it ran for only six hours before it was connected to the furnace.

The engines operated for three weeks in the open air without shelter, and it rained several times; there was also a snowfall of 3 in. Once, the expansion joint on the exhaust line broke, allowing the steam to exhaust directly underneath the engine, which was enveloped in steam for three days before the leak could be stopped.

As the boiler house was near the engines, cinders from the ash heap were blown over them from time to time. This was later stopped to some extent by stretching canvas in front of the engines. As soon as was expedient, a small shed was erected to protect them from the weather until the new power house could be erected.

⁂

A Weir Chart

By Ross J. Brower

A couple of years ago it fell to my lot to calculate and plot a number of curves which would show at a glance the water discharged by a particular weir if the depth of water flowing over it were known. And it was from an inspection of the tabulated results of this work that the idea of a chart applicable to all weirs occurred to me.

The work was based upon the Francis formula,

$$3.33\ (L - 0.2\ H)\ H^{\frac{3}{2}}$$

in which L is the measured width of the weir in feet, H is the depth in feet of the water flowing over the weir, and the resulting quantity is in cubic feet per second or "second-feet." Multiplying second-feet by 448.8 gives the equivalent in gallons per minute. For small weirs this is a common unit. Francis' formula is ordinarily used where the weir has full end contractions—that is, where all the discharge edges are sharp.

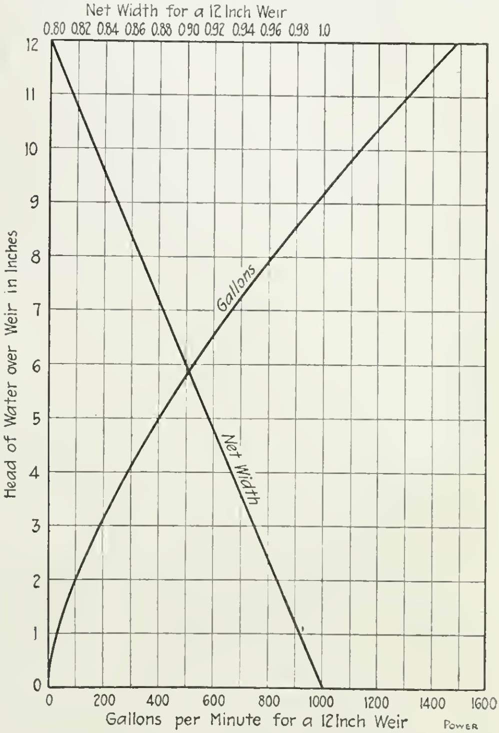
Considering now the factor in the parenthesis, when L and H are both equal to 1 ft., its numerical value is 0.8. Consequently, if the weir measures 2 ft., the stream will measure 1.8 ft.; 3 ft. wide, 2.8, and so on for a depth of flow of 1 ft.

The relation between the depth and the corrected width for a weir 1 ft. wide may be shown graphically by a straight line upon a chart where the depths are marked to scale on a line from the bottom to the top of the chart and the corrected widths are laid off to scale from left to right at the bottom of the chart. The straight line through the two points, $H = 0$, $L = 1$ and $H = 1$, $L = 0.8$, will show the net effective width for any depth of flow.

Now the remaining factors in the formula may also be plotted, using the depth scale already laid off, showing graphically the number of gallons per minute discharged per foot of weir width. In any weir there is only 1 ft. of its whole width which is in any way affected by the contraction produced by the flow past its vertical sides. The true or effective value of this first foot may be read off the straight line for any depth desired. The remaining portion of the measured width not being affected by the end contraction must be added to the effective value of the first foot to get the net effective width of the weir. That part of the formula outside the parenthesis,

$$448.8 \times 3.33\ H^{\frac{3}{2}}$$

is but an expression for the quantity of water in gallons per minute discharged over each lineal foot of width.



Select a convenient gallon scale and for a series of depths compute the numerical values of the above expression and plot the corresponding curve upon the chart.

It is now possible to get the discharge over any weir. For a depth of, say, 6 in., read the effective width of the first foot off the chart as 0.9 ft.; following this 6-in. line to its intersection with the gallon curve, read 530 gal. per min. per ft. of effective width. If the weir is 4 ft. wide, then the effective width must be 3.9 ft. and the discharge over the weir must be

$$3.9 \times 530 = 2067 \textit{ gal. per min.}$$

Thus by simple multiplication the discharge over a weir of any width is readily determined.

⁂

Appalachian Oil Production in 1913—During 1913 the Appalachian oil field, embracing New York, Pennsylvania, West Virginia, southeastern Ohio, and Kentucky, showed a slight decline—1.72 per cent.—in the production of petroleum, falling from 26,338,516 barrels in 1912 to 25,885,640 barrels in 1913—a decrease of 452,876 barrels. The value, amounting to $63,619,677 in 1913, was, on the contrary, increased by 48.58 per cent., about the same proportional increase as was shown in 1912 over the previous year. The figures for each district were as follows:

State	1912	1913
New York	874,128	902,211
Pennsylvania	7,837,948	7,927,137
West Virginia	12,128,962	11,567,299
Southeastern Ohio	5,013,110	4,964,425
Kentucky	484,368	524,568
Total	26,338,516	25,885,640

Stresses in Convex Heads

By F. G. Gasche*

SYNOPSIS—A mathematical analysis of the stresses prevailing at the flange fillet of convex heads. The conclusion is reached that the radius at this point should be as small as possible, although sharp corners must be avoided.

⁂

Recent communications concerning boiler explosions† have indicated sufficient reasons for a critical examination of the formulas by which the important elements of boiler and tank construction are usually estimated. As pointed out by T. T. Parker (Jan. 13 issue), there is a serious omission of the efficiency of rivet joints from the formula for convex heads, particularly those that have to be applied to tanks of large dimensions. Where a head can be flanged from a single plate, the element of safety is thought to be satisfied by the insertion in the formulas of the usual factor of safety, on the supposition that there can be no question concerning the actual stresses existing in any part of the plate. Notwithstanding these calculations and the use of plates of greater thickness than the rules would specify, we occasionally learn of the failure of large convex heads. Unfortunately, the examination of such fractured boiler elements frequently reveals corrosion, crystalline structure, overheating, or initial cracks—any one of which is reprehensible, but nevertheless thought sufficient to explain the primary cause of failure, and quite apart from the question of the weakening effect of rivet joints.

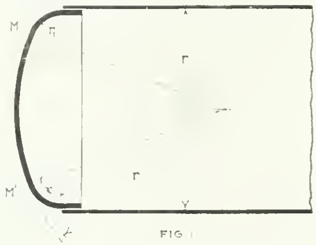


FIG 1

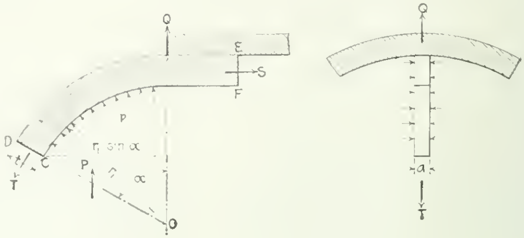


FIG. 2

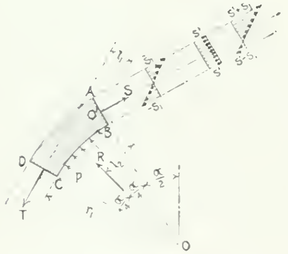


FIG. 3

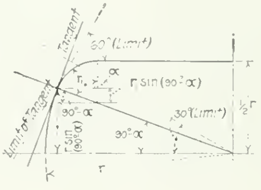
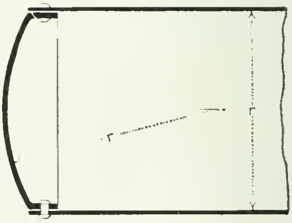


FIG 4



POWER

FIG 5

It will be observed that a great many of the failures of convex heads have been at or near the crown of the flange fillet between the spherical shell and the cylindrical flange. So frequently has this been the region of plate fracture that it was thought advisable to examine the nature of stresses at this point with the hope that more suitable formulas may be evolved. For this purpose the following notation will be employed:

p = Hydrostatic pressure, lb. per sq.in.;
s' = Tensile stress in a spherical shell, lb. per sq.in.;
s_1 = Maximum fiber stress at surface of plate due to stress couple, lb. per sq.in.;
$s = s' + s_1$ = Maximum tensile stress, lb. per sq.in.;
U = Ultimate tensile strength of the plate, lb. per sq.in.;
P = Vertical component of hydrostatic pressure on the particular surface element shown in Fig. 2, lb.;
R = Resultant of hydrostatic pressure on element $ABCDA$ in Fig. 3, lb.;
T = Resultant of all stresses s on the unit area $a\,t$ of section CD, Fig. 3, lb.;
S = Resultant of all stresses on element $a\,t$ of section AB, Fig. 3, lb.;
Q = Reaction on element $CDEFC$ by a *rigid* cylindrical drum, lb.;
t = Thickness of plate in convex head, in.;
a = Width of small radial element shown in Fig. 2, in.;
r = Internal radius of spherical head, in.;
r_1 = Internal fillet radius of the flange extension, in.;
α = Angle of fillet portion of flange extension, deg.;
F = Factor of safety;
E = Efficiency of rivet joints;

---

*Mechanical engineer, Illinois Steel Co.

†See "Power," Jan. 13 and May 19, 1914.

l_1 = Lever arm of force S about the center O' in Fig. 3, in.;

l_2 = Lever arm of force R about the center of O' in Fig. 3, in.;

I = Moment of inertia, $\frac{at^3}{12}$, of exposed rectangular section of plate about a gravity axis.

The stress in a spherical shell is given by the following simple formula as developed in mechanics:

$$s' = \frac{rp}{2t} \qquad (1)$$

If there are rivet seams on the surface of the spherical shell then a safe thickness would be derived from the formula,

$$t = \frac{rpF}{2Es'} \qquad (1a)$$

where F is the factor of safety and E is the efficiency of rivet joints. The stress s' is a simple tensile stress in any tangential direction at any point of a thin spherical shell, and it remains constant for given values of the radius r and the internal pressure p.

This is true for the boundaries M and M', Fig. 1, of a spherical disk formed by the intersection of the shell by a cone having its vertex at the center of the sphere. At such boundaries may be joined other extensions of the plate which do not lie in the spherical surface and yet are surfaces of revolution. Such surfaces form the connection to cylindrical drums and are subject to stresses additional to those of formula (1) in accordance with the local form and dimensions of the plate.

A small portion, $CDEFC$, of a radial element of the plate is shown in section and side view in Fig. 2. The width of the element is supposed to be a small quantity a such that the sides are parallel; the thickness is t, making no allowance for change of thickness due to flanging operations. The element is subject to forces T and S perpendicular to the imaginary end sections, to a restraining force Q, due to the cylindrical drum, and to the hydrostatic (normal) pressure p. There are other forces normal to the sides of the element which occur in pairs and are directly opposed to each other, as shown in the end view, Fig. 2. These forces do not enter the equations for equilibrium of the element.

Taking moments about the point O, Fig. 2, through which the lines of action of all forces p and Q will pass, we find

$$S = T \qquad (2)$$

The resultant in a vertical direction of all the hydrostatic pressures on the flange-fillet section is

$$P = p\, a\, r_1 \sin \alpha \qquad (3)$$

The sum of all the vertical forces on the element is zero; hence

$$P + Q - T \sin \alpha = O \qquad (4)$$

From consideration of formulas (1) and (2) there are operating on the end faces of the element, as areas $a\,t$, the total forces

$$S = T = ats' = \frac{arp}{2} \qquad (5)$$

and, substituting the values from (3) and (5) in equation (4),

$$Q = ap\left(\frac{r}{2} - r_1\right) \sin \alpha \qquad (6)$$

For all practical cases $\frac{r}{2}$ is greater than r_1. The force Q is, therefore, radial as applied to the flange extension of the convex head and tends to open the joint between the head and the cylindrical drum irrespective of the rigidity of the drum. For the sake of simplicity in the analysis it is necessary to assume a perfectly rigid cylindrical drum as a basis for establishing the numerical value of Q. A yield of the structure at the flange connections would seriously complicate the stress-strain relations.

Experiments reported in *Engineering,* to which reference is made in Power of Jan. 13, 1914, seem to indicate that there is a maximum distortion and presumably maximum stress in the head at about the middle of the curve of the flange fillet corresponding to the section AB of Fig. 3. For the present purpose it is assumed that the "dangerous section" is located at the plane AB.

The portion $ABCDA$, Fig. 3, of the element $CDEFC$ is balanced under the following system of forces taking O' as the origin on the neutral axis of the element.

1. A stress couple at the section AB.
2. A uniformly distributed stress due to the force S.
3. Certain shear stresses on the plane AB having no moment with reference to O' and not shown on the figure.
4. The external forces R, S and T.

There are no shear stresses on the plane CD.

The resultant of the normal hydrostatic pressure p on the element $ABCDA$ is

$$R = 2apr_1 \sin \frac{a}{4} \qquad (7)$$

Its line of action passes through the center O and is inclined to the vertical by an angle $\frac{3}{4}\alpha$.

The lever arms of R and T about O' are, respectively,

$$l_2 = \left(r_1 + \frac{t}{2}\right) \sin \frac{a}{4} \qquad (8)$$

$$l_1 = \left(r_1 + \frac{t}{2}\right)\left(1 - \cos \frac{a}{2}\right) \qquad (9)$$

Taking the moment equation about O', with counter clockwise direction as positive,

$$-2\frac{s_1 I}{t} + Tl_1 - Rl_2 = 0 \qquad (10)$$

Hence, substituting the equivalent values in (10) and considering that

$$2 \sin^2 \left(\frac{a}{4}\right) = 1 - \cos \frac{a}{2}$$

we derive

$$s_1 = \frac{6p}{t^2}\left(r_1 + \frac{t}{2}\right)\left(\frac{r}{2} - r_1\right)\left(1 - \cos \frac{a}{2}\right) \qquad (11)$$

The sign of the term involving the trigonometric function is always positive for such angles as would apply to the ordinary dished heads and flanges. We may, therefore, conclude that s_1 is a tension at the point A and a compression at the point B of section AB of Fig. 3. The fillet angle α cannot be less than 60 deg. for the ordinary ratio of drum diameter to radius of spherical head (unity) and seldom exceeds 70 deg.

From (1) and (11), the maximum tensile stress per square inch on the plate at the section AB is (12)

$$s = s' + s_1 = p\left[\frac{r}{2t} + \frac{6}{t^2}\left(r_1 + \frac{t}{2}\right)\left(\frac{r}{2} - r_1\right)\left(1 - \cos \frac{a}{2}\right)\right]$$

When the internal radius r of the spherical head is equal to the inside diameter of the cylindrical drum, the relation between r, r_1 and α are as shown in Fig. 4, where

$$r \sin (90^\circ - \alpha) - r_1 \sin (90^\circ - \alpha) + r_1 = \tfrac{1}{2} r \quad (13)$$

giving

$$\cos \alpha = \frac{\frac{1}{2} r - r_1}{r - r_1} \quad (14)$$

NUMERICAL EXAMPLE—ALL DIMENSIONS ASSUMED

$r = 90$ in.;

$r_1 = 1.5$ in.;

$t = 0.75$ in.;

$p = 160$ lb. per sq.in.

From (14),

$$\cos \alpha = \frac{45 - 1.5}{90 - 1.5} = \frac{43.5}{88.5} = 0.4915 = \cos 60^\circ 33'$$

Then

$$\alpha = 60^\circ 33', \ \frac{\alpha}{2} = 30^\circ 16\tfrac{1}{2}', \text{ and } \cos \frac{\alpha}{2} = 0.8636$$

From (1),

$$s' = \frac{90 \times 160}{2 \times 0.75} = 9600 \, lb. \ per \ sq.in.;$$

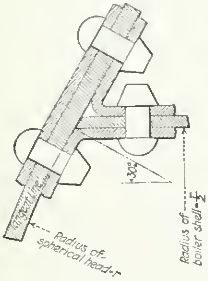

Tangent Line
Radius of spherical head=r
30°
Radius of boiler shell=$\frac{r}{2}$

FIG. 6.

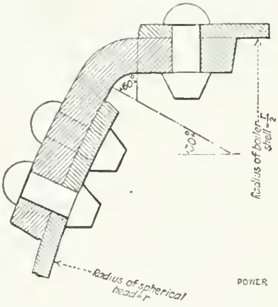

60°
30°
Radius of boiler shell=$\frac{r}{2}$
Radius of spherical head=r
POWER

FIG. 7.

Fig. 6. Proposed Flange Connections for Large Drums, Convex Heads and Moderate Pressures. Fig. 7. Proposed Flange Connections for Large Drums and Convex Heads with High Steam Pressures.

From (11),

$$s_1 = \frac{6 \times 160}{0.5625}(1.5 + 0.375)(45 - 1.5)(1 - 0.8636);$$

$$= 1707 \times 1.875 \times 43.5 \times 0.1364 = 19{,}000 \text{ lb. per sq.in.};$$

$$s = s' + s_1 = 28{,}600 \text{ lb. per sq.in.}$$

This is the maximum tensile fiber stress at the exterior of the flange fillet.

If by such calculations the value of s is found to exceed the elastic limit of the material forming the head, then a set will be produced in the plate, leading to a new and smaller radius r_1 and angle α of the fillet portion. The set which the plate may receive by these stresses permits of some deformation of a portion of the spherical shell which assumes a new and smaller radius r, thus causing a new and more favorable value of the stress s_1, both in magnitude and direction, and a decrease in demands for support on the part of the material in the flange fillet.

The investigation is now sufficient, within the limits of the premises upon which it is based, to indicate that the support of very large spherical heads at their edges should not depend on flange fillets of large radius. On the contrary the fillet radius r_1 should be as small as the circumstances of the manufacture of convex heads will permit, even for moderate sizes of boiler drums. This is a necessary elaboration of the simple requirement that circular rivet seams at the ends of cylindrical drums should be as near to the tangents of the spherical shell at that region as it is structurally possible to place them. For small drums, Fig. 5 shows what form is desirable from the consideration of strength of the head, though it must be understood that sharp corners of flanged plates are not to be tolerated. Fig. 6 is a suggestion of the manner of attaching spherical heads to drums of large diameter as applied to large tanks and relatively small internal pressures. Fig. 7 is a suggestion for large drums intended for high steam pressures.

Formula (11) is proposed for the general conditions involving accidental values of p, r, r_1, t and α. For reasons mentioned above we cannot expect much variation of the fillet angle α, and for the purpose of an empirical formula it will be assumed as 60½ deg. The value of $\left(1 - \cos \frac{\alpha}{2}\right)$ then becomes 0.136. We will also for the same purposes assume that the internal radius r_1 of the fillet is twice the thickness t of the plate. Formulas (11) and (12) then become, respectively,

$$s_1 = 1.02 \frac{rp}{t} - 4.08\,p = 1.02\,p \left(\frac{r}{t} - 4\right) \quad (15)$$

and

$$s = s' + s_1 = 1.52 \frac{rp}{t} - 4.08\,p = 1.52\,p \left(\frac{r}{t} - 2.68\right) \quad (16)$$

The values of the quantity $4.08\,p$ are relatively small as compared with the values of the quantities $1.02 \frac{rp}{t}$ and $1.52 \frac{rp}{t}$ and, therefore, can be dropped from the empirical equations, thus giving somewhat larger values of the stresses, as follows:

$$s_1 = 1.02 \frac{rp}{t} \quad (15a)$$

and

$$s = s' + s_1 = 1.52 \frac{rp}{t} \quad (16a)$$

The maximum *safe allowable* stress is of particular importance in determining proper values for the construction of dished heads. Such values are obtained by considering a factor of safety F and the efficiency of rivet joints E in connection with the ultimate strength U of the plate. Then we have from (16a) for the *safe allowable* stress s,

$$s' + s_1 = s = 1.52 \frac{rp}{t} = \frac{UE}{F} \quad (17)$$

and

$$t = 1.52 \frac{rpF}{UE} \quad (18)$$

In using formulas (17) and (18) it must be clearly understood that they are entirely empirical and are based on a fillet radius of twice the thickness of the plate, and require the specification of the various quantities in the following terms:

s' = Tensile stress in pounds per square inch, due to internal hydrostatic pressure on the spherical portion of the convex head;

s_1 = Maximum fiber stress in pounds per square inch, due to the hydrostatic pressure causing a bending action in the plate at the crown of the flange fillet;

s = Maximum tensile stress in pounds per square inch at the crown or outer fiber of the flange fillet;

p = Hydrostatic pressure of steam, water or gas in pounds per square inch of the internal surface;

r = Internal radius in inches of spherical portion of dished head (taken equal to inside diameter of cylindrical drum);

t = Thickness in inches of plate forming the convex head at the fillet.

COMPARISON OF CALCULATIONS FOR CONVEX BOILER HEADS BASED ON VARIOUS RULES

These are based on the assumption that the diameter of the cylindrical drum is equal to the radius of the convex head. The formulas are reduced to the consideration of a convex head without rivet joints on its surface, using a factor of safety of 5 and a tensile strength of 55,000 lb. per sq.in.

Massachusetts, Ohio and U. S. Government

$$t = \frac{rpF}{2U}, \qquad p = \frac{2tU}{rF} \qquad \text{(I)}$$

T. T. Parker

$$t = \frac{8.33\,rp}{2U}, \qquad p = \frac{2tU}{8.33\,r} \qquad \text{(II)}$$

F. G. Gasche

$$t = 1.52\,\frac{rpF}{U}, \qquad p = \frac{tU}{1.52\,rF} \qquad \text{(III)}$$

Case 1. Diameter of drum 48 in., thickness of head 0.75 in. To find the allowable pressure.

By formula (I), p = 344 lb.
By formula (II), p = 206 lb.
By formula (III), p = 113 lb.

Case 2. Diameter of drum 90 in.; thickness of head 0.75 in. To find the allowable pressure.

By formula (I), p = 183 lb.
By formula (II), p = 110 lb.
By formula (III), p = 60 lb.

Case 3. Diameter of drum 42 in.; pressure 200 lb. per sq.in. to find the thickness.

By formula (I), t = 0.382
By formula (II), t = 0.636
By formula (III), t = 1.162

Volume Regulator for Air Compressors

A new volume regulator, which can be applied to air compressors to control the amount of intake air and reduce the power required to operate the compressor in about the same proportion, is manufactured by the Hall Steam Pump Co., 201 Galveston Ave., Pittsburgh, Penn. By its use, the amount of intake air can be regulated to correspond to the compressed air consumed at any time, thereby keeping the receiver pressure constant, and any desired constant volume within the capacity of the compressor can be delivered. It can be applied to any kind of air compressor with automatic inlet or outlet valves, or both.

The feature of this regulator is that, in case the automatic suction valves are used for regulation, they are kept open by force during a part only of each discharge stroke and close as soon as the intake air remaining in the cylinder has decreased, so as to correspond to the compressed air desired at the time.

If the automatic discharge valves are used for regulation, they remain forced open during a part only of the following suction stroke, and close as soon as the compressed air returned into the pump cylinder is so great that, after expansion to the intake pressure, it will leave sufficient room for the entire quantity of compressed air to enter the cylinder during the last part of the suction stroke.

Closing the automatic valve at an adjustable point during the return flow of the air is effected in a gradual regulation of the force holding the valve open against the pressure exerted by the spring. The return flow of the air through the valves produces a pressure tending to close them, which will constantly increase until the piston has reached the end of its stroke, or very nearly so. The valve will close at the point where this pressure, supported by the pressure of the valve spring, balances or overcomes the force applied for the purpose of regulation.

Fig. 1 shows the application of the regulator to an ordinary poppet-valve air compressor and acting upon a suction valve to keep the receiver pressure constant. The main piston works in a power-driven compressor cylinder. The suction valves have springs which tend to close them; and pistons which are acted upon by the air pressure in their cylinders. These cylinders are connected by a pipe to the auxiliary tank. The latter communicates with the atmosphere through a leak, and with the main reservoir through the opening, which is closed by the automatic needle valve as soon as the force of the adjustable spring above it overcomes the air pressure of the reservoir, acting on the bottom of the needle-valve piston.

An adjustable hand needle valve can be arranged to obtain a constant leak from the main to the auxiliary reservoir, thereby preventing the pressure in the latter from decreasing below a certain value.

When the compressor is working at a constant partial load, the automatic needle valve will allow some air to enter the auxiliary tank through the valve opening, and the same quantity of air will escape through the leak to the atmosphere, thus keeping the pressure in the reservoir and the pressure acting on the piston in the main cylinder constant. The suction valve will close at such a point of the discharge stroke as to compress exactly the quantity of air consumed, the pressure in the storage tank remaining at constant.

An increase or decrease in the consumption of air will cause a slight momentary decrease or increase of the pressure in the main tank and the air entering the auxiliary reservoir through the needle valve will decrease or increase. This so changes the pressure in the reservoir and the cutoff of the suction valve as to increase or decrease the intake air until new conditions of equal supply and consumption of compressed air are established at the same pressure as before.

For a certain pressure in the auxiliary tank, the air compressor will work at its maximum capacity. The object of the adjustable needle valve is to admit constantly so much air to the auxiliary tank as to produce this pressure. If more air be admitted through the hand needle valve, the capacity of the compressor will be reduced and the volume of the intake air will vary with the consumption only as long as the latter remains below its reduced capacity.

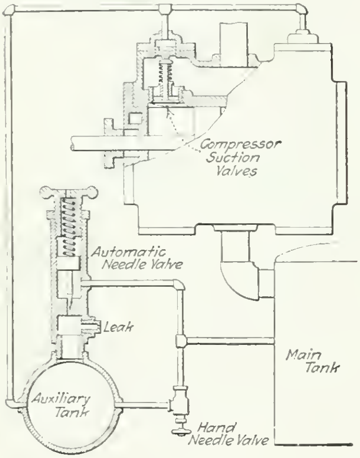


Fig. 1. Application of the Regulator to Poppet-Valve Air Compressor

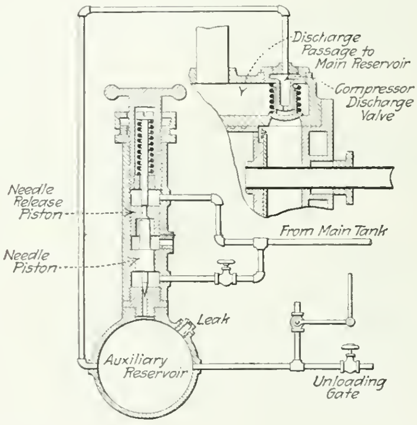


Fig. 2. Application to Regulation of Discharge Valve of Piston-Inlet Type Compressor

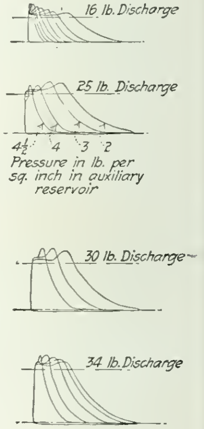


Fig. 3. Indicator Diagrams from Pressure-Regulated Compressor

Fig. 2 shows the regulator applied to a compressor having piston-inlet type of discharge valves.

When the compressor is working at a constant partial load, the air under pressure from the main tank will enter the chamber above the needle-valve release piston, through the pipe shown, and counteract the tendency of the spring to raise the piston, which will therefore bear upon its extension, so carrying the needle valve against the pressure entering the chamber through the pipe that the air will enter the auxiliary reservoir through the passage shown at the same rate as it escapes through the leak. This will keep the pressure in the reservoir constant, which, through the pipe leading from it and the opening shown, acts upon the cylindrical discharge valve. Under these conditions, the pressure in the auxiliary chamber will be somewhat less than that in the main tank and in the passage leading from the cylinder to that tank.

Owing to the low pressure thus carried in the plungers of the discharge valves they will be kept open during part of the following stroke, and allow a certain amount of compressed air to reënter the cylinder from the outlet passage and expand in the cylinder to the intake pressure. During the remaining part of the suction stroke, the fresh air drawn into the cylinder will correspond exactly to the consumption of compressed air at the time, the air in the main tank remaining constant.

When the compressed-air consumption is increased, a slight momentary drop of pressure in the main tank results. The spring above the needle valve will then overcome the effect of the tank pressure on the piston and it will rise, thereby allowing the needle piston carrying the needle valve to lift and a greater quantity of air from the tank will enter the auxiliary chamber. The pressure in the auxiliary tank will increase, and acting through the discharge-valve plunger will cause the discharge valve to seat at an earlier point of the suction stroke. This increases the volume of fresh air drawn into the compressor through the intake valve until it equals the increased consumption of compressed air taken from the main tank, the pressure in the tank being kept the same as before.

In case of a decreased consumption, similar action will take place and a new equilibrium between the supply and the consumption will be established after a slight momentary increase of the tank pressure.

The unloading globe valve allows enough of the pressure air in the auxiliary tank to escape to the atmosphere to load the compressor by hand if desired. A similar valve is opened by means of a speed regulator, if the speed of the prime mover falls below a certain value and it is desired to unload the compressor in that case.

Fig. 3 shows a series of indicator diagrams taken in a service test on an ordinary poppet-valve air compressor, with bypass, equipped with the volume-regulating device.

Bristol Pneumatic and Electrical Recording Tachometers

The Bristol pneumatic-type recording tachometer has been developed to continuously record the speed of shafting and machinery. A special feature of this tachometer, Fig. 1, is the 25 or more feet of flexible connecting tube between the revolving mechanism and the recording instrument, which may be mounted in any convenient position. The instrument is manufactured by the Bristol Co., Waterbury, Conn.

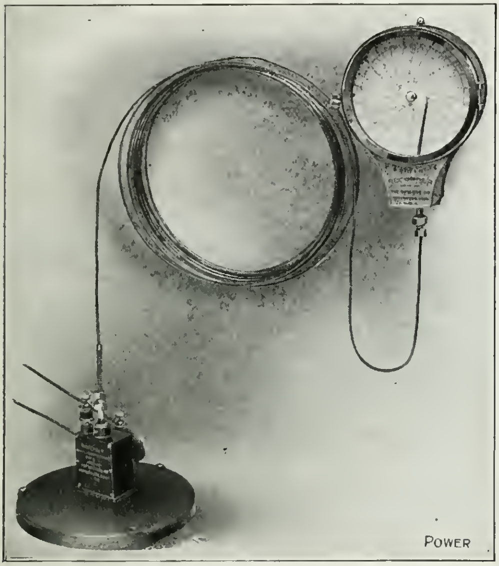


Fig. 1. Recording Tachometer

The pneumatic principle of operation depends on the centrifugal action of air in a revolving tube which is connected to the recorder through a special oil-seal, flexible connecting tube. The hollow circular protecting base at its upper surface is provided with a bearing for a hollow shaft *D*, Fig. 2, arranged to be rotated from any desired mechanism through a set of gears and pulleys or sprockets.

The pulley *C* is belted to a similar pulley attached to the shaft whose revolutions are to be measured and recorded. The lower end of the hollow vertical shaft *D* terminates in a horizontal tube *A*, open at its extremities. The upper end of the hollow shaft is surrounded by a casing *E*, and is partly filled with oil; into this extends the free end of a stationary tube joined at its outer end to a flexible capillary connecting tube *G* leading to the recording instrument. The recorder used is a special, low-range recording vacuum gage.

The Bristol electric tachometer of the alternating-current type, Fig. 3, is suited to rough operating conditions in mills, power plants or shops. Two of its main features are the induction magneto and the voltmeter movement. The magneto, being of the induction type, is without any sliding contacts or brushes. The indicating and recording instruments are voltmeters. The indicating instrument has a Weston pivot jewel-bearing voltmeter movement, and the recording instrument has an improved Bristol voltmeter movement designed with enough power for actuating the recording arm with the pen in contact with the chart. The movement is mounted on frictionless knife-edge bearings and has a new supporting device for the moving elements designed to eliminate temperature error. This recorder can be furnished for either 6-, 8- or 12-in. charts.

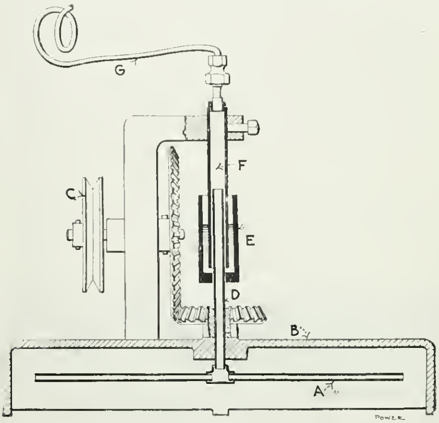


Fig. 2. Details of Revolving Mechanism

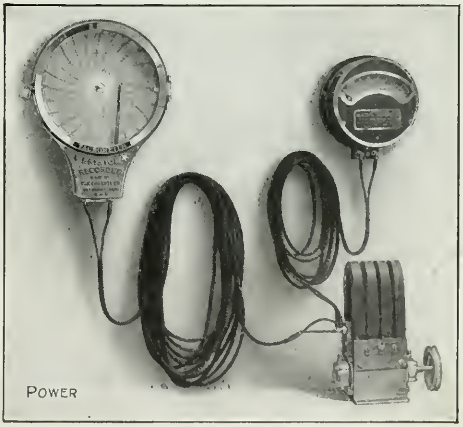


Fig. 3. Electrical Tachometer

Suitable lengths of leads can be furnished for placing either instrument at desired points and there are connections for more than two instruments. A simple form of this tachometer can also be had either with the indicator or the recorder alone.

⁂

Coal Mining in Indiana—The first commercial coal mining in Indiana, according to E. W. Parker, of the United States Geological Survey, was done by the American Cannel Coal Co., at Cannelton, Perry County, in 1837. The coal was mined along the Ohio and Wabash rivers. In 1840 the production was 9682 tons. The record for production was made in 1910, when it was 18,389,815 tons; the production for 1913 was 17,165,671 tons.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—We find a combination of electrical units whereby either the small direct-current and alternating-current unit could be run as a motor or generator. This permitted shutting down at times either the direct-current or alternating-current main, engine-driven units and still generate direct and alternating current. At another mine a combination haulage system was operated, using a second-motion haulage engine and an electric locomotive.

*

Cresson, Penn., is at the top of the mountain, and is accustomed to hand out all kinds of weather. Hunter and I reached the town the next forenoon after our uncomfortable night with bug exterminators and paint. The sun was shining, but an overcoat felt comfortable, especially when a cloud covered the sun and a driving snow squall would rage for half to three-quarters of an hour. We experienced several of them that day.

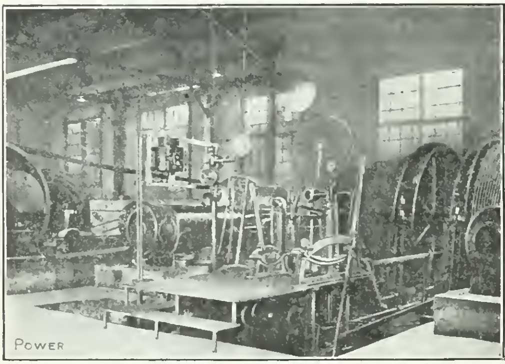


Fig. 1. Hoisting Engine in the Main Engine Room

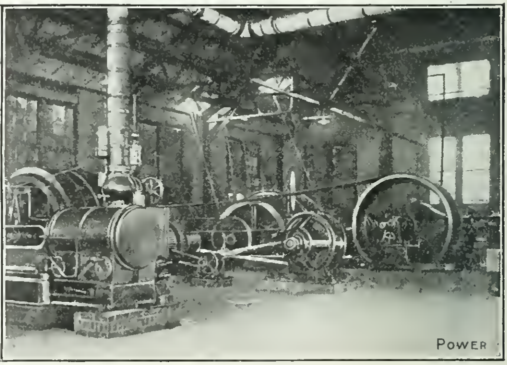


Fig. 2. The Two Reciprocating Units Belted to Generators

Obtaining permission at the office of the Pennsylvania Coal & Coke Co. to inspect the outside mine workings, we first went to Cresson No. 9 shaft. Here we found a 24x42-in. first-motion hoisting engine, Fig. 1, with an 8x10-ft. drum working on a shaft 530 ft. deep. Two veins were worked, one being at the 300-ft. level.

This engine was housed in one end of the power plant which consisted of one 15 and 25 by 15-in. tandem-compound, side-crank engine, belt connected to a 200-kw. alternating-current, two-phase, 60-cycle, 2300-volt generator at 900 r.p.m. This unit was used to light the town of Cresson.

"A central station at the mines," remarked Hunter upon being told of the use to which the units were put.

"This unit," said the superintendent, who was showing more friendly attention than we had any right to expect, "has a 20x21-in. cylinder and is directly connected to a 200-kw., 250-volt, direct-current unit for mine use.

"We have a combination in those two units and the two motors that is exceptionally convenient. The alternating-current machine lights the town at night, as I have said. The direct-current generator supplies the mine day and night when the mine is working. In case of a shut down of the mine the direct-current machine is stopped and the alternating-current generator is not only used for commercial circuits, but also to operate a 100-kw. alternating-current motor, which belt-drives a 90-hp. motor used as a 250-volt, direct-current generator to supply electrical energy to the mine for whatever purpose desired up to the capacity of the machine.

"When the mine is operating, the large direct-current generator is used, but the 90-hp. motor which was driven as a direct-current generator is run as a motor from the large direct-current generator and drives the 100-kw. alternating-current motor as an alternating-current generator for lighting the town and mine. Of course, these machines are all controlled from the switchboard.

"One of the greatest difficulties in operating electrical units about a mine is in keeping them clean, especially if they are of the open type."

"That's right," agreed Hunter, "I once saw a good-sized direct-current generator get on fire in the inside of the armature winding. The engineer, feeling a little chesty had blown himself to a cigar and was smoking it while on duty. A spark from the cigar was drawn into the armature, which set fire to the accumulation of dirt, and it was not long before the engineer found the machine smoking like a young volcano. The machine had to be shut down while the engineer was busy attempting to kill the fire, and, fortunately, was successful before the armature was damaged."

"We have found," resumed the superintendent, "that for our particular circumstances and conditions that it is to our interest, taking all things into consideration, to purchase considerable electrical energy. For that reason we have several substations for converting purchased high-voltage alternating current into direct current for use in the mines."

After some further talk we proceeded to one of the substations, Figs. 3 and 4, located at the Gallitzin No.

10 slope. Here we found a neat brick building in which was a motor-generator set on one side of the room and the transformer for reducing the line current down for motor use. The energy came to the transformer at 4500 volts and was transformed down to 2300 volts to drive the 430-hp. synchronous motor which was directly connected to a 1090-amp. direct-current generator which supplied the five 13-ton electric locomotives used in the main haulage, two 3-ton gathering locomotives and 16 electric chain cutting machines. Direct current is necessary in mine electric locomotives because alternating-current motors do not satisfy the speed and space requirements. That is why rotary converters are used in so many mines taking high-voltage alternating current and transforming it down to low-voltage direct current."

"Yours is not the only mine that has found the rotary converter to be useful as well as reliable. Many of the larger mining companies have built central power plants, either steam or hydraulic, at suitable points, and transmit the high-tension alternating current to the mine, miles away, where it is converted to direct current. Generally this current is used at either 275 or 600 volts."

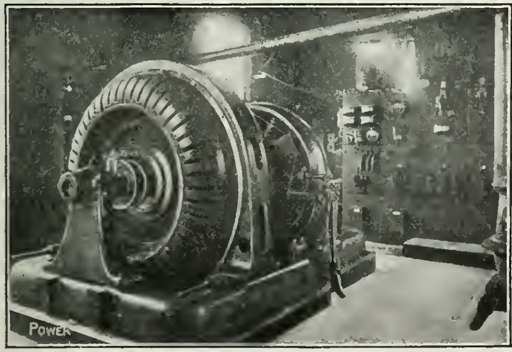


FIG. 3. MOTOR-GENERATOR UNIT

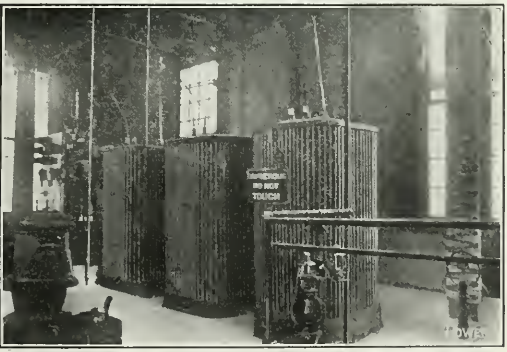


FIG. 4. HIGH TENSION TRANSFORMERS

"What is the reason the substations are always on top of the mine?" I asked as we made our way back to the railroad station.

"They are not," replied Hunter. "In some of the large mines it is sometimes advisable to locate the converters underground near where the converted current is to be used. Such a station should be lined with brick, and made waterproof on the outside. The ceiling should also be water-tight so that dripping water cannot damage the machine. The high-tension current is generally led to the underground substation by armored lead-covered cables through bore holes, which lessens the chances of injury from falling rocks, etc."

We had inspected, some weeks previous, the substation at Truesdale colliery in which was a 500-kw. rotary converter taking current at 4000 volts from the power plant and sending it out for direct-current use at 275 volts. A second rotary converter of about one-half the capacity also supplied 275-volt current for mine use. The alternating side of these machines ran on six-phase, 60-cycle current at 450 and 900 r.p.m. respectively. The units are shown in Fig. 5.

Arriving at the railroad station we waved a farewell to our host from the rear platform and then went into the smoking compartment to punish a couple of stogies.

"I should think there would be danger of shock from those overhead trolley wires," I said as I mentally calculated the amount of clearance that must have been between my head and the wire in the last mine we had been in.

"There is," said Hunter, shifting one leg over the other. "There are three dangers from electricity in mines; that from shock of touching the trolley line or other base conductor or from touching something that, through worn insulation, has become charged with electricity. Then there is the danger of a spark setting off gas or dust, which may occur when a motor is working under a heavy load.

"While the sparks from a motor would not be sufficient to ignite coal dust the flash from an open circuit might, or the flash from a heavy short-circuit would be dangerous. The danger from fire is due to the vicinity of inflammable material to a flashing motor or a circuit wire grounding. I have been told that certain sizes of incandescent lamps will, if broken, ignite any surrounding explosive mixture of gas and air.

"Electricity in coal mines has made great strides in recent years. According to the Bureau of Mines, in Pennsylvania, from 1902 to 1911, the horsepower developed at anthracite mines had increased from 354,223 to 671,802. Most of this increase was underground work, pumps, etc., but the increase for electric locomotives was from 53 to 635 in number. You can see that where these machines are used the mule has had to step to one side. In the anthracite mines there are said to be more than 15,600 mules, each worth about $250, something like $3,900,000. As the average life of the mine mule is about five years, there are $780,000 expended each year for mine mules. That rather knocks the mule, doesn't it?"

"You mentioned the cost of the power plant, necessary for the operation of either air or electric locomotives. I should think one large central station of sufficient capacity to provide electrical energy for all of the mines controlled by one company in any particular district would be a logical conclusion. But for all that we have found that each colliery has a steam plant of its own."

"Well, that used to be the idea, but in recent years the operators have come to see that electric energy can be transmitted cheaper than steam or compressed air can be delivered through a pipe. There are a number of coal companies generating all of the power used in their several collieries in a single station. You see the operating expenses are cut way down, for one shift of men in the one power plant will supplant half a dozen or more shifts employed at the smaller plants. All coal is distributed to the one plant, which, with the refuse, can be handled more cheaply than when distributed among several plants."

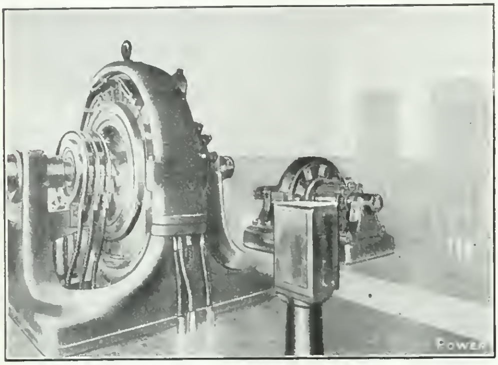


Fig. 5. Two Rotary Converters for Mine Service

"Of course," I said, "it is cheaper to keep large turbines or reciprocating units in proper shape than it is to keep a large number of small units in condition. I suppose the saving would be in excess of the interest charges on the additional investment. How about that?"

"That is right, and the operating expense is further reduced by the apparatus running condensing in most cases of large units. In these large installations alternating current is generally used, but direct current can be generated to good advantage when the distance of transmission does not bring the cost of the copper-transmission wires to a prohibitive point. Now, electrical energy is measured in watts which is the product of the voltage multiplied by the amperes. That is, if the voltage is 250 and a load of 1000 amp. is carried by a line, the line would be carrying 250,000 watts, or 250 kw.; there being 1000 watts in a kilowatt. If the same amperes were carried, but at a voltage of 500, the load on the line would be 500 kw., or just twice that at 250 volts. So long as the amperage remains the same, the voltage can be increased to 1000, 1500 or 2000, or practically any amount and the same wire will carry it.

"It is usual to keep the line drop, or the loss of voltage due to the resistance of the wire, within 5 per cent. for a long line, or 2 or 3 per cent. for a short line. To carry a given load in kilowatts, either the wire must be large enough or the voltage high enough so that, in relation to the current (amperes) carried, the wire capacity will be sufficient to insure a low line drop.

"But you see direct-current motors are not designed to use voltages much above 600, on account of commutator sparking, and the danger the exposed brushes, etc., would be to workmen. For these reasons if voltages higher than 600 to 650 volts are desired alternating current is used, using a motor generator or rotary converter to change the alternating current to direct current for mine use."

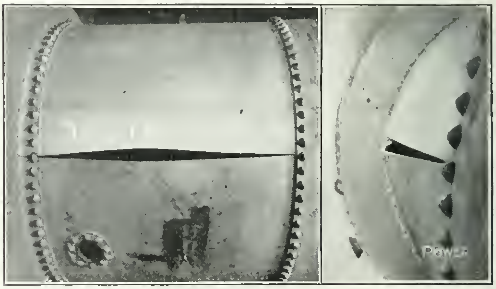
Just then the train drew in at our station and we reluctantly gave up our comfortable seats in the train to jolt over rough stone paving in a swaying bus, which cumbersomely made its way to the hotel. After a good supper we agreed to visit a mine central power plant the next day to see just what kind of equipment was to be found.

Nut Lock

In a nut lock manufactured by Sehum Brothers, Metropolitan Tower, New York, N. Y., the nut is provided with internal slots. The bolt is slotted and in the slot is a threaded segment backed up by a helical spring. The end of the bolt is drilled and tapped for a round-head machine screw, which normally holds the threads of the segment in pitch with the threads of the bolt. When the nut is almost down to its seat, the machine screw in the bolt end is slacked back, which permits the threaded segment to be forced by the spring out of pitch with the threads of the bolt when the next internal slot in the nut is in line with the segment. To remove the nut the machine screw is tightened to force the threaded segment again into pitch with the threads on the bolt.—*American Machinist.*

Surprising Results of Boiler Destruction Test

The photographs show the result of a hydrostatic test to destruction of a boiler built 23 years ago which was to be used as an open tank. It was of the following dimensions: The shell, 61 in. in diameter, had 182 fifteen-foot tubes rolled in but not beaded. It was of the three-course, lap-seam, double-riveted construction, having $\frac{1}{2}$-in. shell and tube sheets. The pressure was applied with the idea of showing the weakest part.



Unsuspected Flaw in a Sheet

It was expected that the tubes would be first to show distress, but when the pressure reached 320 lb. the lower course next to the ogee split as shown. The sheet bulged out about 3 in. The lower tube sheet dished about $\frac{3}{8}$ in., while the upper remained perfectly straight, and all the seams and tubes were tight. It was estimated that the shell should withstand at least 600 lb.

Editorials

Fallacy of Cheap Grate Bars

It is surprising that the trade persistently demands cheap grate bars. One would think that those able to appreciate the necessity for good material and workmanship in castings for high-duty pumps, locomotive cylinders and the like, would see the need for such qualities in their grate bars. Nevertheless, when the importance of good grate bars is urged, the usual response is: "Why, they're only grate bars! What's the use—the fire will only burn them up, anyway." It is the old weakness for substituting "something just as good."

The idea seems to be that when a grate bar burns out, any old thing will do just so it will hang together. If the fire is kept from falling out, no attention need be paid to the reduced draft area and the restricted combustion.

Rough appearance and absence of both machine finish and paint deceive the user into thinking that any kind of iron will do to make a grate bar. A superfine quality of foundry iron is not urged, though there are many places where such material is none too good. The iron should be sound, hard, well knit and homogeneous. The long service this kind of bar will give amply repays the extra cost. It is almost criminal to spoil a well designed firing chamber by the use of inferior grate bars when it is so essential that they be properly designed and proportioned.

The bulk of the grate-bar business is in the hands of the small country foundries, which make them of scrap agricultural machinery castings, hard as flint and full of dirt. The fact seems to pass unnoticed that the openings come filled up; that they soon crack and burn, and that their closed vents call for harder firing and more coal.

Flagrant disregard for economy in the operation of the plant causes us to wonder why, in this age of efficiency, so many men persist in standing in their own light in the important matter of grate bars.

Consulting Engineering Gratis

Knowledge and ability are not acquired without hard work and expenditure of time and money.

Besides attending to routine work, most engineers, whether consulting or operating, find it expedient to specialize in certain branches of the art. They become exceptionally well informed in these directions, their friends know of it and tell their friends, and soon a man's reputation for a particular class of work is established.

Unquestionably this is good for the man, but there is a constantly growing tendency to use such men as "good things." To a degree, this practice is not objectionable, for, after all, there is much truth in the question: "What good is a friend if you cannot use him." To this should be added "so long as he is not misused." If one goes to a doctor or a lawyer friend and seeks advice, he is charged for it. Why not? Doctors and lawyers do not become such solely for the salvation or satisfaction of their friends, and neither do engineers.

We know many engineers who, by hard study and costly experimenting, have so informed themselves that they excel in certain directions. Most of them are not consulting engineers, but operating men, who have large plants under their supervision; who are burdened with heavy responsibilities, who must not only direct, plan and foresee in a general way but must devote considerable time and effort to many details, each seemingly insignificant in itself but the cumulative effect of which means much.

These men are busy. Their time is valuable. Their employers do not pay them to spend an hour giving Mr. Jones some information about this, nor for having a fifteen-minute telephone conversation answering Smith's question about that, or for using a stenographer twenty minutes to reply to a letter from Mr. Brown, who wants enlightment on "just this one little point."

If there were but one Jones, Smith or Brown, it would be a pleasure to give the information requested, but when there are many, and the total time consumed amounts to hours each week, then it is time to call a halt.

This situation exists with many men. They are broad, willing fellows, all of them. They are always glad to oblige and never wish to offend, but, when about to use their time to enlighten you on "this one little point," remember that there are many "points" and many who seek enlightenment. You are asking for professional service gratis; unintentionally, unknowingly, misusing a good man and reducing the business of consulting engineering to mere panhandling.

More Foolish "Editation"

In an editorial entitled "More Foolish Legislation," the *Hotel World* protests against passing laws for examining and licensing stationary engineers to handle heating boilers. The remonstrance sparkles with gems like this:

> The explosion of steam-generating boilers, notwithstanding the millions of them in use, is a thing so rare that notwithstanding every such accident is reported in the press, weeks go by without such a report appearing in the prints. It is true that once in a while a locomotive or other high-pressure boiler, carrying from 50 to 200 pounds pressure, explodes. But there is far more danger to humanity from falling street signs than from steam boilers carrying from one to twenty pounds of steam for heating purposes.

As the compilation of accidents to boilers in the last issue shows, there were over five hundred accidents last year that we heard of, and doubtless many more, so that the high-pressure variety go off a little more often than "once in a while," and not many "weeks" went by between any two accidents.

As for the low-pressure boilers being no more dangerous than "falling street signs," we cannot say. We have no statistics of the killed and injured from falling street signs. We can show, however, that last winter there were several serious heating-boiler explosions. We specially commented on some of them and were so impressed with the importance of a contention the very opposite of that of the *Hotel World*, that we directed attention in our issue of May 5, 1914, to the necessity of guarding life and property from heating-boiler explosions.

A little later in the *Hotel World's* editorial, we come to the thing that makes the legislation foolish in the editor's eyes:

> The proposed statute would mean for a hotel, during at least the winter months, when steam heat is demanded night and day without interim, three licensed men for each hotel, for men will not and the law will not now permit men to work 12 hours in 24. The difference between a licensed man controlled by union schedules of wages and common firemen is the difference between $3 to $5 per day per man for three men and $25 to $50 per month for two men.

Taking the worst figures cited, it would cost a hotel $450 a month instead of $25 to $50. Is not that a terrible price to pay for the increased safety of its guests during the winter? If the journal we are criticizing fairly reflects the attitude of its field, the editor of this paper hopes to do all his traveling in the summer, when he can stop at a hotel without feeling that he is sleeping over a gunpowder mine.

Finally, our contemporary knocks all the force out of its argument with this closing sentence:

> No sane or sensible business man objects to inspection or supervision, because some plants should have it, nor does he object to competent employees, but to compel an employer to hire a $150 man to take care of a $50 job, when the danger is as remote as it is in the use of low-pressure boilers, is to work a graft for unionism and, in the last analysis, load an unjust burden on hotel patrons, for they in one way or another must pay the freight in the final equation.

If the hotel patrons have got to "pay the freight" anyhow, what is all the kick about? Perhaps they care enough for their own safety to pay a few cents more a day rather than take chances of being blown through the roof. Who knows?

⁂

The Value of Tools

The repair item is more important in determining the actual cost of power turned out by a plant than is generally realized. It is not merely the amount of money spent for repairs as shown by the balance sheet that is important, but what economies are obtained from its expenditure. If such sums are spent judiciously and the desired results achieved, the savings therefrom accrue during every day of subequent operation. Remedying each defect, regardless of size, as soon as it is discovered, does its share toward cutting the power cost.

Broadly speaking, the money for plant upkeep is spent in one of two ways. One is to give the plant a thorough overhauling at definite intervals; meantime no effort is made to do repair work. This generally means dismantling important units, replacing expensive parts, and calling in outside workmen, whose cost in wages and incidental expenses is much greater, man for man, than the cost of the regular employees of the plant. Heavy expenditures for repairs coming in a lump also naturally cause an unfavorable financial showing for the time being. The other method is for the plant's operating force to attack, instantly upon discovery, with such resources as they possess, all defects, great or small. It is a pleasure to any engineer to work with good tools and shape metal into useful devices; it is second nature for him to tinker. Furnish him the means and he immediately begins to think of ways to keep in proper order and to improve the equipment under his charge.

What can be better policy than to utilize this natural desire for handling tools to keep the plant equipment up to maximum efficiency? In every power house there is a quantity of small apparatus which is constantly wearing out and the neglect of which means an unnecessary increase in the cost of operation. Chronic neglect of this minor equipment eventually results in sending for outside aid and in heavy repair bills, which must be paid in a lump. Constant attention to the upkeep of these same small details by a plant force equipped and instructed for the work results in repair bills being reduced to the minimum and spread over such a wide period of time as not to prove burdensome financially.

Some owners of power plants hesitate to invest in a few of the simpler machine tools on the ground that they would be used only occasionally and would not earn the interest on their cost. One thrifty electric-light plant overcame this objection by establishing a tool fund, to which was credited such small miscellaneous revenue as was derived from the sale of scrap metal and similar sources not connected with the company's regular business. Whenever the amount in this fund was sufficient, some useful machine tool was purchased. A blacksmith's forge, drill press, emery wheel, electric drill and a small engine lathe were eventually acquired. Thus in a few years this company had not only a well maintained, smoothly operating plant, but also an auxiliary repair shop, which in itself was a valuable asset.

The effect on a plant's operating force of putting tools into their hands is wonderfully bracing. With the responsibility of the plant's maintenance put up to them, latent energy and ambition are sure to be awakened. That most important element for cutting power costs, the interest of the men themselves, is thus aroused and made of permanent benefit to the plant.

⁂

A side light on a central-station failure is the following newspaper report of the conditions at Meridian, Miss., after the explosion of a boiler at the central power plant supplying current to many private consumers besides the street lighting and traction system.

> As a result of the explosion, the city is in darkness, the street cars are standing on the tracks over the city at the places where the current went dead and kerosene lamp and tallow candle are doing duty in the places where there are no gas fixtures. The elevators are standing still, and in several plants automobile engines have been installed to furnish power. Daily papers are being issued under difficulties. The "Star" got out this afternoon half size by using an automobile engine as motive power; the "Morning Dispatch" has had a large gasoline engine installed to pull its press, and motorcycles will pull the battery of type-setting machines.

All the eggs seem to have been entrusted to one basket.

⁂

The number of instances in which convex boiler heads have failed at the heel of the flange has been sufficient to indicate, at least, that there is something radically wrong with the generally accepted formula for figuring the strength of such heads. In the present issue, Mr. Gasche makes a very complete analysis of the stresses in this region of the head and his deductions show that a much higher factor of safety is demanded than it has been customary to allow. A careful perusal of Mr. Gasche's article is recommended to all interested in the manufacture or operation of steam boilers.

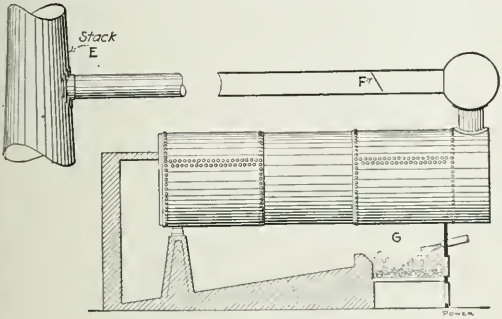
⁂

Copies of the index to POWER for the first six months of 1914 (Vol. 39) will be ready for distribution in about two weeks and will be sent without charge to subscribers requesting them.

Correspondence

A Boiler Test

In a recent boiler test steam jets were used as a basis of smoke prevention. These jets were placed above the grate, as shown in the illustration, and were of the inductive type—that is, they carried in a volume of air with the steam. They had valves for individual control, and were so arranged that they could be entirely cut off. One trial of a day's duration was run, with steam jets, and one without, and an exact measure of water and coal was noted in each trial. The results are shown in the accompanying table.



Draft Tested at E, F and G

	With Blower	Without Blower
Duration of test, hr	9	9
Steam pressure, lb.	96.5	97.07
Feed water, deg. F	139.3	139.67
Total feed water, lb.	40,091.0	35,481.5
Total coal, lb.	4,860	4,440
Moisture in coal, per cent	2.06	2.06
Coal, B.t.u.	13,840	13,840
Coal, per sq.ft. grate, lb.	11.87	10.85
Evaporation of, lb.	8.25	7.99+
Draft at E, in.	0.66	0.66
Draft at F, in.	0.42	0.30
Draft at G, in.	0.17	0.22
Flue gas temperature, deg. F	434.25	398.5
Room temperature, deg. F	83.00	89.00
Per gas analysis CO_2	9.36	8.76
Per gas analysis O	9.12	10.93
Per gas analysis CO	0.33	0.25
Per gas analysis N	81.19	80.03
Boiler hp. rating	155	155
Boiler hp. developed	144	127.25

While the test shows a slight gain by the use of the steam jets, I should say it was mostly due to the change of draft conditions during firing when the coal was generating its greatest and was quickly burning the gases, which in turn would naturally obviate smoke. Note the change of velocity of the moving gases at the point *F* in the stack connection. This would be largely responsible for such bettered conditions, as it is not always well to have an increased furnace draft.

Frequently, we have boiler trials that show too much grate-surface draft, while the increased temperature of flue gases would tend to increase the draft at the point *F* and above. On the other hand, the tests run without steam jets were made with a less horsepower: consequently there was a lower gas velocity, due to the stack-base temperature.

I should not take this test seriously in behalf of the use of steam jets at this point for smoke abatement. While this did run a cleaner stack top, we would naturally look for this from the conditions set forth. Still this test is of interest to the power-plant operator, notwithstanding the gain is only 31 lb. of coal to the 1000 lb. burned.

C. R. McGahey.

Baltimore, Md.

*

Cost of Operating a Vacuum Ash-Handling System

In the April 7 issue, there is an article describing a vacuum ash-handling system, with some figures on the cost of operation which are probably correct so far as they go, but they give no idea of the total cost of handling a ton of ashes. The item—5.29c. per ton—covers the cost of steam only, which is but a small part of the total cost, as can be readily shown.

Let us assume a plant of four 400-hp. boilers, three of which are in constant operation at their rated capacities. With a boiler horsepower on 5 lb. of coal and the ash content of the coal 12 per cent., we would have

$$1200 \times 5 \times 0.12 = 720 \textit{ lb.}$$

of ashes per hour. Assuming the plant has ash hoppers with capacity sufficient for a day's operation, we would have

$$\frac{720 \times 24}{2000} = 8.64 \textit{ tons of ashes per day}$$

According to the reported test, seven tons of ashes were handled in an hour. This would require the services of two men to feed the ashes into the pipe—rapid work being necessary to prevent a waste of steam. With two men at 20c. an hour and working at the above rate, the labor charge per ton of ashes is

$$\frac{2 \times 20}{7} = 5.71 \textit{ cents}$$

For a plant of this size, the apparatus completely installed would probably cost $1800, say, $1000 for the tank and $800 for the piping. With 6 per cent. interest on an investment of $1800, this charge against a ton of ashes is

$$\frac{1800 \times 0.06 \times 100}{365 \times 8.64} = 3.42 \textit{ cents}$$

The depreciation of the ash tank is at least 8 per cent. On an unlined tank it would be more, because of the corrosive action of the wet ashes. In either case, the baffleplate would require frequent renewal. The depreciation of the ash pipe is high—fully 40 per cent. The effect of ashes striking a bend in the piping while traveling at a high velocity can be appreciated only by those who have had experience with such things. At the above rates, the depreciation charge per ton of ashes is

$$\frac{1000 \times 0.08 + 800 \times 0.40}{365 \times 8.64} = \$0.1268 \textit{ or } 12.68 \textit{ cents}$$

Adding the foregoing, we have

$$5.29 + 5.71 + 3.42 + 12.68 = 27.10 \textit{ cents}$$

as the cost of handling a ton of ashes.

To dispel any suspicion that the assumptions made are unwarrented, I will say that I had some experience with a vacuum ash-handling system in which the vacuum was maintained by a so called "positive blower" which was driven by a back-geared 50-hp. motor. The average life of the manganese-steel wearing backs (2½ in. thick) at the bends was 11 days. These wearing backs were replaced by plugged tees, but the power required to operate was such that the 50- was replaced by a 75-hp. motor. The cost of handling a ton of ashes at this plant was 26c., exclusive of fixed charges. The system was abandoned for a mine car and skip hoist.

Gebhardt's "Steam Power-Plant Engineering" describes a vacuum ash-handling system like the one just referred to. It winds up with the statement that "the cost of handling the ashes in this installation is approximately 7c. per ton." Now, anyone working up the data given will find that the 7c. would no more than cover the cost of power, and does not include labor, maintenance or fixed charges.

It seems to me that plants are exceptional where a vacuum ash-handling system is indicated, and that it cannot successfully compete with handling with wheelbarrows where the length of travel is moderate.

I'll confess that it is a pretty thing to see ashes disappearing through a hole into a pipe, the ashes ending their journey in a tank placed over a railroad track, but the novelty soon wears off when the operating costs become known.

C. O. Sandstrom.

Kansas City, Mo.

* * *

Thermocouple Connection

In the April 21 issue an article entitled "Gas Producer Testing," referring to gas temperatures, contains the statement, "To make corrections for the increased resistance, due to the heating of the cold junction of the thermocouple above its calibrated zero mark, a mercury thermometer should be so suspended that its bulb will rest on the junction, thus showing to how much this heating amounts." This statement becomes misleading when the principle of the thermocouple is explained. A thermocouple has two wires of different composition; say, for instance, one of copper and one of iron. These are joined at one end, which is inserted into the furnace and called the hot junction, the two free ends being connected either directly to the reading instrument or to copper leads which run to the reading instrument.

The point where these ends outside of the furnace connect, either to the instrument or to the copper leads, is called the cold junction, and it is the difference in temperature between the hot and cold junctions which is the source of electrical energy. If the hot and cold junctions were at the same temperatures, there would be no electrical energy developed and, hence, no indications would be shown on the reading instrument as there would be no temperature difference between the two junctions.

In commercial practice, the cold junction temperature of the thermocouple is assumed to be around 70 to 100 deg. F., which is average room temperature, and the zero mark on the reading instrument is from 70 to 100 degrees.

Should an instrument be set with a zero mark of 100 degrees and the actual temperature at the cold junction be about 200 degrees, it would read low by approximately 100 degrees, depending upon the characteristics of the thermocouple. This applies to most base metal thermocouples; with a platinum thermocouple, the reading would be low by approximately 40 or 50 degrees. Therefore, the statement is misleading that corrections should be made for "increased resistance due to the heating of the cold junction."

Where platinum and platinum rhodium or "rare" metal couples are employed, the resistance so increases with the temperature that the current generated is cut down and, should the resistance of the indicating instrument be nearly that of the couple, a serious error would result. The only practical method of overcoming this is to use a reading instrument of high resistance so that slight changes in the resistance of the thermocouple and wiring will be negligible.

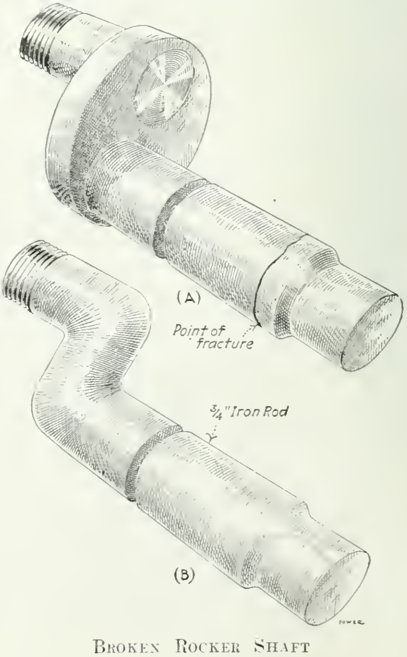
Joseph C. Schwarz.

Rochester, N. Y.

* * *

Emergency Repair to a Duplex Pump

Because of a defect in the material, one of the rock shafts on our duplex pump broke close to the valve-motion lever, as shown at *A*. As it was necessary that the pump be kept running, a piece of ¾-in. iron rod was hastily bent in the shape indicated at *B*, dressed



Broken Rocker Shaft

up with a file, and after threading one end for the nut it was put in place of the broken shaft. The pump ran satisfactorily until a new shaft was secured.

ERNEST A. TICHENOR.

Beechwood, W. Va.

Selecting a Pump

In the May 12 issue, Mr. Webster is quite correct in believing that the lowest-priced article is not always the cheapest, and if he had carried his investigation still further, he probably would have chosen a more suitable installation.

A horizontal centrifugal pump, where there is a suction lift, is seldom the best pump. It requires a foot valve which is usually hard to maintain tight, especially when using river water with its attendant sand and other solid matter. When the pump is at a distance, as in Mr. Webster's case, the time spent going to the pump to stop the leakage of the foot valve and consequent loss of priming is a serious item. If no check valve were placed in the discharge line, the pump would always be primed, but the loss of water might be serious since there would be no way to tell just how great the leakage through the foot valve might be.

A better installation is a vertical submerged pump placed in a small concrete pit at the river side, with the suction line running through the pit wall or over the top of the pit into the river. Eliminating the foot valve and placing a check in the discharge line would prevent the water in the tank from running back through the pump. Even with a 7-in. pump, the extra cost of the vertical type should not exceed $100 plus the cost of the concrete pit.

Mr. Webster states that the maximum demand does not exceed 675 gal. per min. Since the triplex pump furnishes 268 gal., the centrifugal pump has but 407 gal. per min. to furnish. Furthermore, it appears that the total hourly water consumption is such that the centrifugal pump is in operation five times an hour for periods of 4½ min. each, or a total of six hours per day.

Pump D, the one chosen, requires 19.63 hp. per hour, or the daily power required for the six hours of operation is

$$\frac{19.63 \times 746 \times 6}{1000} = 87.86 \textit{ theoretical kw.-hr.}$$

A squirrel-cage motor of this size would have an efficiency of about 85 per cent., so the actual power required to pump the water would be

$$\frac{87.86 \times 100}{85} = 103.4 \textit{ kw.-hr.}$$

However, there is a serious loss that occurs in this method of pumping that must be considered.

Each time the motor starts it requires about three times the running current to bring it up to speed; this demand lasting for about 15 sec. Consequently, the power required to start the motor five times an hour, or 80 times a day, would be

$$\frac{19.63 \times 746 \times 100 \times 3 \times 15 \times 80}{1000 \times 85 \times 60 \times 60} = 17.2 \textit{ kw.-hr.}$$

The transformer loss would average about 3 per cent. for both the active and the idle periods during the 24 hr., or, using a transformer capacity of 20 kw., the loss would be

$$\frac{20 \times 24 \times 3}{100} = 14.4 \textit{ kw.-hr.}$$

Then the total power required for the pump would be

$$103.4 + 17.2 + 14.4 = 135 \textit{ kw.-hr. per day}$$

A better solution would have been to use a pump which by continuous operation each hour would, together with the triplex pump, supply the hourly consumption. The 7-in. pump now delivers 15,750 gal. per hour, so a 2½-in. pump delivering 275 gal. per min. would be able to meet the hourly demand.

Of course, it is possible that the demand is a varying one and that the amount and period of demand coincide with the capacity and running period of the 7-in. pump, namely, 700 gal. for 4½ min. However, the elevated tank need hold only 4100 gal. to handle all the water delivered by the triplex pump and the 2½-in. centrifugal pump during the 7½ min. when the factory demand is zero. If the demand at night is light, then the small pump could be handled by automatic control, as is the 7-in. pump at present.

Figuring the total days pumping from the present operation, then the 2½-in. pump need run 16 hr. per day, made up probably of 12 hr. continuous operation and 4 hr. intermittent pumping of eight 30-min. periods. Using the same discharge line as at present, the friction loss would be so decreased that the total head would approximate 75 ft. instead of 80 ft. as at present.

It is possible to obtain a 2½-in. pump with an efficiency of 65 per cent., while a motor of the required size should approximate 85 per cent. The power requirement would figure as follows:

$$\textit{pumping} = \frac{5.2 \textit{ hp.} \times 100 \times 746 \times 100}{65 \times 1000 \times 85} = 7 \textit{ kw. per hr.}$$

$$7 \times 16 = 112 \textit{ kw.-hr.}$$

$$\textit{starting power} = \frac{7 \times 3 \times 15 \times 8}{60 \times 60} = 0.7 \textit{ kw.-hr.}$$

$$\textit{transformer loss} = \frac{7.5 \times 24 \times 3}{100} = 5.4 \textit{ kw.-hr.}$$

Total power required equals

$$112 + 0.7 + 5.4 = 118.1 \textit{ kw.-hr.}$$

The saving over using the 7-in. pump would be

$$135 - 118.1 = 16.9 \textit{ kw.-hr. per day}$$

or

$$16.9 \times 300 = 5070 \textit{ kw.-hr. per year}$$

which, figured at 2½c. per kilowatt-hour, is $126.75 per year.

L. HARVEY.

Waco, Texas.

Hints on Starting a Compression Plant

William L. Keil's article, in the June 2 issue, on this subject deserves criticism, as some of his statements are misleading. He states that there are many types of refrigerating machines, some with "oil system," others without; those without he calls "dry systems."

By oil system I infer that Mr. Keil means the oil injection as used in the De La Vergne type of refrigerating machine. This injection has two purposes, to fill the clearance spaces in the compressor and to cool it. The latter is a strictly dry-gas machine.

Ammonia compressors not using the oil injection are not all dry systems or dry-gas machines, as Mr. Keil would have us believe. There are two systems of running ammonia compressors, the wet and the dry.

In the wet system the ammonia gas returning from the evaporator is in a wet or saturated condition. Therefore its name, "wet compression." In this system the frost line is carried back to the machine; in fact, the suction parts of the compressor should be well frosted. No water is used in the jacket with this type of compressor as the cold and saturated condition of the ammonia vapor returning to the compressor will keep it sufficiently cool without the aid of jacket water.

In the dry-compression system the frost line is carried up to within 5 or 10 ft. of the suction valves; hence the returning ammonia gas is dry or slightly superheated. In this system of ammonia compression a water jacket and water circulation through the compressor is necessary to carry off the heat due to compression.

There has been much dispute among refrigerating engineers as to the relative merits of these systems. Nearly all ammonia compressors are fitted with water jackets so that they can be run either dry or wet.

"In starting up, see that the equalizing valves are open," states Mr. Keil. In my experience I have found few compressors excepting motor-driven ones that have had equalizing valves between the suction and discharge sides of the compressor. Hence, Mr. Keil's statement applies only to a few compressors.

Mr. Keil states that the water should not be turned on the condenser until the pressure has risen to the working pressure usually carried. This, in my opinion, is bad practice. It is far better to turn the water on the condenser as soon as the compressor is started, or a little before, as the lower the condenser pressure—to a certain point of liquefaction—can be held, the more economically and efficiently the machine can be run, as the lower the condenser pressure, the more gas the machine can handle per revolution.

If the condenser be allowed to run without any water until the desired working pressure is reached, it is quite evident that the condenser is warm, if not hot, and turning cool water suddenly on a hot condenser is not good engineering practice. The sudden cooling effect of the water on the hot condenser is liable to start a series of leaks due to the sudden contraction of the pipes and joints on the condenser. These leaks are sometimes hard to find and most troublesome to repair.

It is far better, in my opinion, to turn the water on the condenser before starting the compressor so that the condenser and compressor will heat up slowly and evenly to the temperature of the working pressure.

As to the statement about direct and indirect systems of refrigeration, I have found that the direct system is more extensively used in smaller plants and hotels than is the indirect system. The direct system of expansion eliminates brine pumps, brine tanks, agitators and a lot of piping, which makes it a favorite over the indirect or brine system.

A little further on Mr. Keil states that the brine should never be lower in density than 79 deg. or higher than 90 deg. Bé. This statement is erroneous, as 90 deg. Bé. would mean a solution of approximately 80 per cent. salt and 20 per cent. water, which is almost a solid mass. I believe Mr. Keil means 70 to 90 deg. on the salometer instead of the Baumé scale. Seventy-two degrees on the salometer scale at 64 deg. F. is equal to 18 deg. on the Baumé scale and the specific gravity is 1.140, while 92 deg. on the salometer at a temperature of 64 deg. F. is equal to 23 deg. on the Baumé scale and the corresponding specific gravity is 1.186.

Calcium brine with a specific gravity of 1.186, or 23 deg. Baumé, can be cooled to 5 deg. below zero without any danger of freezing.

C. E. Anderson.

Chicago, Ill.

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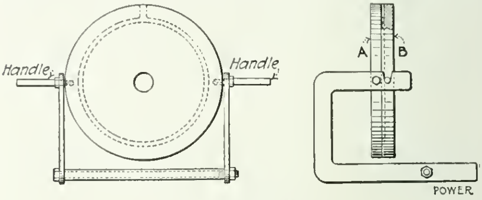
Lead Boiler Gaskets

The article on this subject, by J. C. Hawkins, in the Apr. 28 issue, was interesting. I have seen lead gaskets used in several plants and they have been entirely satisfactory.

The illustration shows the simplest and most convenient mold that I have seen. Plate *A* is flat and bolted to a stand made of two strips of wrought iron bent as shown. Plate *B* has a groove for the desired size of gasket. The two handles serve another purpose by fitting into the beveled slots in the stand and holding plate *B* firmly against plate *A*. This is handier than dowel pins and capscrews. When more than one size of gasket is needed, another plate, like *B*, is made with the desired size of groove.



Lead-Gasket Mold

Lawrence Kjerulff.

Kansas City, Mo.

*

Preheating Furnace Air

A great deal has been published lately in Power about boiler-room economy, but I have seen nothing like my system.

We had considerable hot water (condensate) of 200 deg. and over that we did not know what to do with except let it cool in a large tank; this seems to be general practice. I reasoned that if a few degrees difference in the feed water made a saving, then a few degrees difference in the air under the grates should make a saving also.

I cleaned out behind the bridge-wall and put in a lot of old pipe coils, making a large radiator; then I connected it to a pump to get a circulation of the hot water through the coils. By roofing this over and making some holes through the bridge-wall below the grates and one large one in the side of the setting, we had it fixed so that all of the air for draft had to pass over those coils, when the front ashpit doors were kept closed.

We have no way of determining the amount of saving, but by measuring the coal I am convinced that at least 15 per cent., and possibly more, was saved.

M. A. Olmstead.

Sterling, Kan.

The Horsepower of a Rainstorm

Recently, there was a severe rainstorm in this locality, and when talking to an engineer about it afterward, the question of its horsepower arose. I was interested enough to hunt up data on which to base a calculation.

The rainfall amounted to 4.17 in. in 10 hr. over a surface of approximately 10 square miles, and the estimated average height of the rain cloud was 5000 ft. This represents approximately 6,000,000,000 lb. of water which had fallen during 10 hr. from an elevation of 5000 ft., or 15,000,000 hp.-hr. Thus we see the energy represented by this one short storm.

Suppose man could avail himself of this energy and store it so it could be used at pleasure; for instance, for lighting city streets with 4000 arc lamps. Allow 500 watts per lamp, making 2000-kw. load during the lighting period equal to 2680 hp. or, including losses, say, 3000 hp. Allowing 12 hr. in 24 as the lighting period, the daily load will amount to 36,000 hp.-hr.

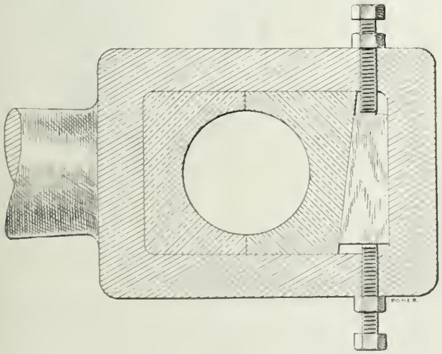
The length of time this energy would last would be 425 days, or one year and two months of light from one storm. This gives some idea of the enormous energy at work in nature.

G. P. Pearce.

Moline, Ill.

Allowance for Expansion

I knew that brass expanded more than iron, but in this case I was caught. As shown in the illustration, it was a solid connecting-rod end for the crankpin of a fairly large horizontal engine. As there was a slight knock I stripped the brasses to what were my ideas of a nicely running fit. I was told by the engineer that it had a habit of heating up quickly and that previous engineers had tried to tighten it.



Type of Stub-End

It went nicely for about one hour when there was not much load. Thinking it was all right, I went to some other work, but the engineer soon said it was heating and he would have to stop. The heat was not great, but the engine was being slowed down by the crankpin being gripped. It only took a few minutes to ease the adjusting screws and start the engine. I then reasoned that as the connecting-rod was heavy and solid, when the crankpin and brass heated, the brass was forced to expand on to the pin, so that to escape a stop if there was a chance of the journal heating it would be necessary to allow for the expansion of the pin and brass. On other rod ends where the brasses expand away from the pin, the joint surfaces of the brass being fairly large, the bolts will yield slightly and do not pull up the engine so quickly. After a few weeks I had it adjusted to the original position in which it had seized and it ran all right. This experience may save someone trouble, and reasoning it out afterward.

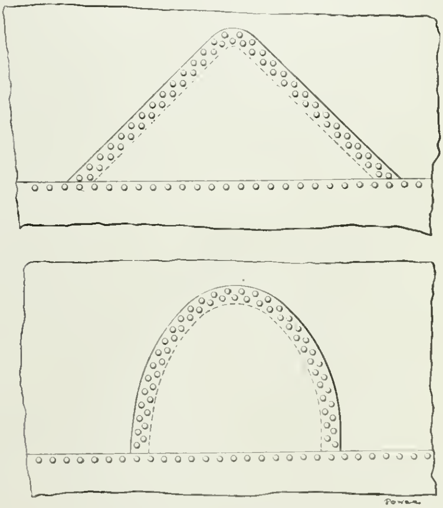
W. Burns.

Govan, Scotland.

Patching Boilers

Some time ago I was asked this question, though I was not perfectly sure of the answer:

"If you had a horizontal tubular boiler constructed according to the Massachusetts rules, with a quadruple-riveted butt joint having an efficiency of 94 per cent., and a bag should form on the bottom of the fire sheet 30 in. long (lengthwise of the boiler) by 20 in. wide, beginning at the girth seam, how would you put on a patch, and have the boiler as strong as before?"



Which Form Is Best?

My answer was that I should make the patch triangular in shape with the point well rounded, and use a double row of rivets on the sides of the patch with a single row in the girth seam if originally it was single riveted. I have failed to find any formula that would apply to this kind of joint.

If the patch is made square, as it usually is, the lap-riveted, longitudinal sides would be of lower efficiency than the longitudinal seam of the boiler, and as the girth seam usually has a higher efficiency than the longitudinal seam I reasoned that a joint of triangular shape would have a higher efficiency than one of the usual shape.

I have never seen a patch put on in this manner, and perhaps there is some good reason for its not being done. I would be pleased to read the views of other engineers on its feasibility, and get a suitable formula for laying out the patch, spacing the rivets, etc.

J. C. HAWKINS.

Hyattsville, Md.

Superheaters Flooded

Superheaters in use at the present time in central stations are standard as a rule; consequently the following can be applied:

These superheaters are flooded or filled with water previous to lighting the fire. When the pressure reaches approximately two-thirds that carried on the line, the water is blown out so as not to have water in the path of the steam when the boiler is cut in.

In practice there should be no moisture in the steam after it leaves the superheater, but sometimes a tremendous amount of water will be thrown into the steam line and it is at times quite a difficult matter to determine where it is coming from. Frequently it is leakage at the flooding valve, where a slight leak will not be noticed if the boiler is being fired at anything near its rating. Where a boiler has been banked over a period of several hours and is then fired up quickly, the leak will have partly filled the superheater and be thrown into the line. Therefore, there should always be placed a small valve just in front of the superheater blowoff. Then before firing up or replenishing the banks, this valve should be opened to the atmosphere and if water is present it can be blown out before the bank is disturbed. This bleeder can be bypassed to a trap, but it should always have an open connection for observation. If the flooding valve is kept tight there would be no use for the foregoing, but it is handy to inspect the condition of the flooding valves. Nickel seat and disk valves for use on the superheaters give the least trouble.

JOHN F. HURST.

Louisville, Ky.

Wrong Stator Connection

The synchronous speed of an induction motor depends upon the frequency of the circuit from which it operates and upon the number of poles on the stator. A motor designed to give rated speed on a 50-cycle circuit will run above normal speed on a 60- and below normal speed on a 40-cycle circuit. Increasing the number of poles will decrease the speed obtainable from a given frequency, and decreasing the number of poles will increase the speed obtainable from that same frequency. The stators of all modern induction motors are wound with formed coils, and a change in the number of poles ordinarily calls for change in the pitch; hence, in the dimensions of the coils. That this point may be overlooked is illustrated by the following incident, due in a measure to the fact that the same frame may be wound for two or more pole arrangements.

A four-pole, 60-cycle induction motor was struck by lightning and had to be rewound. The rotor, which had been operating for two years, had been running at a speed of 1800 r.p.m., which was correct for the work that it had to do. After its return from the repair shop, the motor was unable to turn out the work that it did formerly, and on measuring the speed it was found to be only about 1200 r.p.m. As nothing had been handled except the stator, it was suspected, and the difference of exactly 600 r.p.m. was suggestive. Investigation revealed that in connecting the stator it had been connected to give six poles instead of four. On reconnecting for four poles, the original speed was restored.

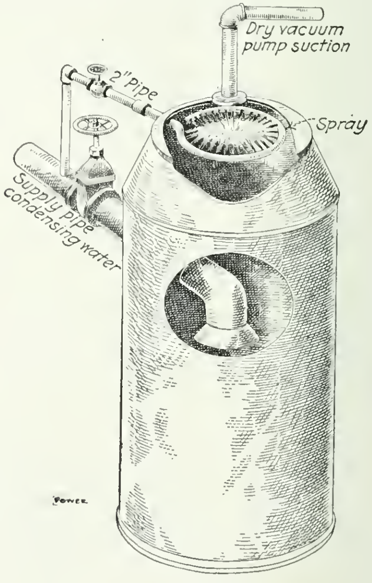
J. A. HORTON.

Schenectady, N. Y.

Increasing the Capacity of a Vacuum Pump

The efficiency of a dry-vacuum pump on a jet condenser can be increased greatly by cooling the air or vapor before it enters the pump.

To obtain this result some makers expose the air outlet as much as possible to the cooling effects of the entering water. Where the water supply is limited, however, and the amount used is reduced as the load decreases, the pump must handle considerable steam or hot vapor due to poor distribution. This does not occur under full-load conditions. An air cooler can be installed consisting of a ring made of 2-in. pipe with $\frac{1}{8}$-in. holes drilled upon $\frac{1}{2}$-in. centers on the inner diameter, which will suffice for air outlets up to 16 in. in diameter. All of the air or vapor must then pass through the spray which will reduce its temperature and volume.



AIR-COOLING SPRAY

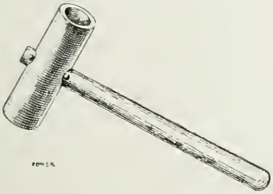
The water used should come from the injection supply and outside of the injection valve. There need be no fear of water being lifted and carried to the pump as the velocity of the air under conditions of high vacuum is very low; therefore the spray water will fall into the condenser. Such a spray could not, of course, be used on surface condensers.

JOHN F. HURST.

Louisville, Ky.

Hammer Made of Steam Hose

When trying to drive back a large dent in a sheet-etal oil tank or filter with an ordinary hammer usually number of small dents results. To overcome this diffiulty, use a hammer made of a short length of heavy team hose, as shown.



Hammer Made of Hose

Charles Fenwick.

Humboldt, Sask., Can.

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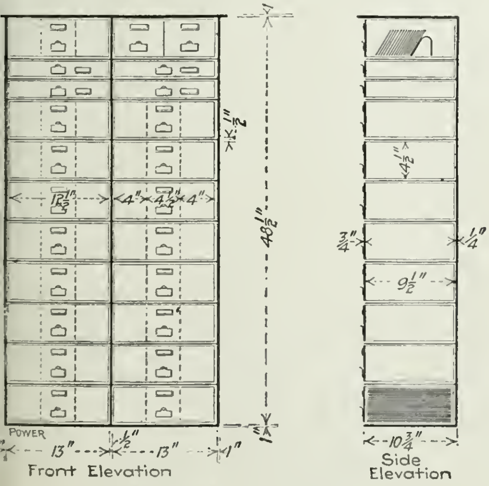
Filing Magazines

It puzzled me to find a good and inexpensive way of inexing and arranging my engineering journals. I tried inding them, but the volumes were too cumbersome to ike to the plant or to read on the street cars, and someimes a fellow engineer wanted an article on a certain ubject.

I solved the problem in the following manner: I made cabinet, a front and side view of which is shown. It is 0½ in. high, 28½ in. wide and 10¾ in. deep. The ides, top, bottom and front are made of one-inch boards, he back and drawer bodies of one-quarter inch; the parition of one-half inch. It was then painted and the ulls and label holders attached. It contains 16 drawers ½x12½ in. and 4¼ in. deep inside measurements. Each rawer will hold one year's issues of Power with the adertisements removed, each issue being loose.



A Magazine Filing Cabinet

At the back of the drawers an opening of 4½ in. wide was made as shown by the dotted lines, so that the journals can be easily removed. I put a strip of heavy paper between the first and second half year for convenience.

There are four drawers 1¾ in. deep for clippings on selected subjects. Two of the top drawers are used for index cards, which are 6 in. wide, 9½ in. long and 3¼ in. deep. The other is for the yearly magazine index. This cabinet was made during my spare time and the material cost about $5.

When I have several issues on hand, I remove the advertisements and clinch the wire staples. Then I mark the articles and card index them under suitable headings, so that I can find them (sometimes I index them under more than one heading) and then I mark the front page with a capital *I*, so I will know that it has been indexed. I use the index on the inside of the front cover as I find that it explains the contents of the article in a brief way. I abbreviate as much as possible and keep a list of the abbreviations used. For instance *P* stands for Power and also page; "ill.," illustrated; "col.," column; "E. N.," *Engineering News*, etc. I also index interesting articles in books.

It is most satisfactory to have a place for magazines and the interesting articles indexed so that they may be easily found and can be carried around conveniently.

K. J. Lawrence.

Kansas City, Mo.

⁂

Centrifugal Pump Would Not Pump

At least 50 per cent. of the trouble with centrifugal pumps results from faulty suction conditions. The following problem illustrates one of the cases where the blame was placed on the pump, whereas it belonged to the method of piping.

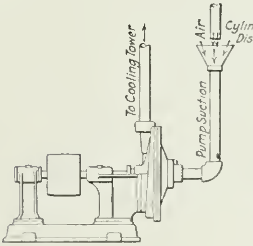


Fig. 1.

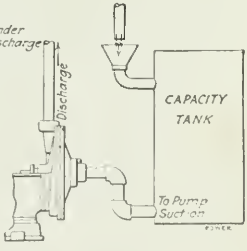


Fig. 2.

Water from the city mains had been used to cool the cylinder of a machine-shop gas engine. The cooling water required, some two thousand gallons per hour, had always accounted for excessive water bills. A refrigerating engineer suggested using the water over and over by putting up a cooling tower on the roof of the shop. The result was the installation of the belt-connected outfit, Fig. 1.

The water from the cylinder jacket had always been discharged to a funnel and piped to the city sewer. A tee was put in and connections made so as to discharge this water direct to the pump suction. It was desired to keep the open connection so as to know that water was flowing at all times.

Everything completed, the pump was started. The funnel overflowed but no water was discharged from the pump. A larger driving pulley was used to speed up the outfit, but still no results. After some studying the suction was connected to a barrel which it rapidly pumped dry. Connections were then made, as shown in Fig. 2, the pulley size was reduced to the original, and water was easily handled by the pump.

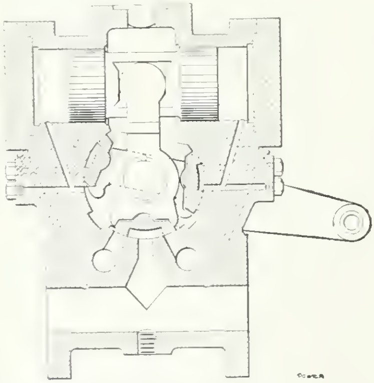
The trouble was evidently caused by air being drawn into the funnel and trapped in the impeller. This air once trapped was not thrown out fast enough to permit the impeller to get a grip on the incoming water, which was also full of air. With the plan, shown in Fig. 2, the air bubbles came to the top of the tank, while water, free from bubbles flowed to the pump impeller, forcing out any air that may have been trapped. The pump has a slightly greater discharge than that of the engine cylinder and so drains the tank. It then runs idle until water rises and flows to the impeller.

H. C. Wight.

Philadelphia, Penn.

Emergency Repairs at Sea

By a series of coincidences the same type of accident happened on two large mail steamships on the same design of feed pump which had been recently installed. This was the breaking of the valve spindle, a rod 2⅛ in. in diameter made of mild steel. The spindle has an oscillating movement of about one-quarter turn and receives its motion from a balanced lever, which is actuated by a tappet rod connected loosely to the crosshead of the piston and bucket rods.



As may be seen in the illustration, the valve operated by this 2⅛-in. spindle is only to start the motion of the main valve and open the steam ports, by which the main valve receives the steam that actually gives it motion. Thus the torsion stress on the spindle is slight and when under full steam the gear can be operated by hand.

The first accident, as were also the others, was a scarf break just behind the rocking lever. The spindle was taken out and the pieces carefully held together in a vise, while a ¾-in. hole was bored through with an ordinary ratchet brace.

One-half of the hole was left clearance size and the other tapping size, so that when a tap bolt was screwed in tightly the pieces were brought together and held securely. This done, the spindle was replaced in its position on the pump and a split clip with holes, similar to those in the stem, top and bottom, was clamped over the fracture. The top bolt was screwed through the clamp and spindle and drawn up tightly. Then the clamp bolts were tightened up and the projecting threads of the bolts burred over to prevent slacking back on the nuts as there was not sufficient space to allow locknuts to be used. Then the dismantled part was replaced and the pump restarted in a little over two hours after the breakdown.

While this repair carried the ship to port, the bending stress loosened the arrangement so that it was just a question of time before another repair would have to be effected. A new spindle was fitted, and three months later the same trouble was experienced when only two days from port and five days steaming ahead of us, so that a more substantial job would have to be done if the pump was to be kept working for that period.

On this occasion, the hole was bored as on the previous repair, but instead of the split clip an old nut was filed out 1/32 in. less in diameter than the stem. Then the holes in the spindle were slightly countersunk so that on riveting the ends of the tap bolt they would not project beyond the circumference of the stem. The tap bolt was screwed home and the ends cut off, leaving sufficient to fill the countersink on the stem, riveted over and filed up smooth to the spindle's periphery. This was necessary as the spindle had to be passed through a neck bush and gland to get it back in working position.

When in place, the nut filed out was made white hot and shrunk on over the break and tap bolt. When cold this made the repair quite solid, and it held until the home port was reached, when a new stem of slightly larger diameter was fitted and no further fractures have occurred on that particular pump.

These two accidents were quickly followed by two similar ones on a sister ship, and as different engineers were in charge different ideas of repairing the break were evolved. The broken parts were sawed off and a square filed in the rocking lever. Then a ¾-in. tapping hole was bored in the center of the spindle parallel to its axis, the spindle replaced in the pump and connected up to the rocking lever. A tap bolt and washer held the lever securely on the squared end of the spindle.

This arrangement shortened the spindle considerably and took the center line of the rocking lever away from the center line of the tappet rod, which was of forked design with a pin through the fork and lever. To connect this up a piece of pipe was cut to fill the inside of the fork and a long bolt passed through the rocking lever, with a bit of pipe as a distance piece, then through the eye of the fork of the tappet rod and screwed up hard with a nut on both sides of the fork, so that the lever was free to move while the bolt was held fast.

This method resulted in the square being wrenched off through a flaw in the material. Another square was filed as large as possible and as this further shortening of the stem brought the boss of the lever up against the gland nuts, they were cut off flush with the gland, which was held in place by the lever boss. Then the bolt to connect to the tappet rod was lengthened. The job **with-**

stood three weeks' wear and tear, when port was reached and the spare spindle from ashore was fitted and the pump given an overhauling.

C. G. Bennie.

Itchen, England.

Steam Jets

Steam jets are often employed to increase the draft or to keep the grate bars from burning. From the writer's point of view, this principle seems entirely wrong. The amount of steam used may be found by Napier's rule; that is, the weight of steam a jet will pass in pounds per second when discharging into the atmosphere. Following is the formula:

$$W = \frac{pa}{70}$$

where

W = Weight in pounds per second;
p = Absolute pressure in pounds per square inch;
a = Area of orifice in square inches.

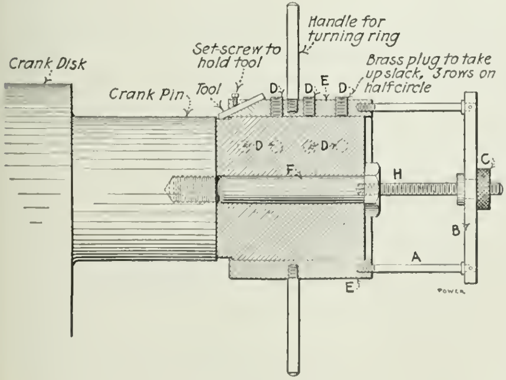
To my mind, a fan would require only about one-half the amount of steam and at the same time give the fireman much better control over his fire.

E. R. Pearce.

Rochdale, England.

Truing Crankpins

The sketch shows a device which I made to true up some 6-in. pins. The following describes its makeup: The guide or supporting pin is secured to the crankpin by a bolt which fits the hole in the end of the crankpin; the feed screw is tapped into the head of the bolt. The crossbar B is secured to studs A by pins. The knurled hand feed C is made in two parts in order to assemble in crossbar B. Brass take-up plugs D, tapped a snug fit, are to hold the turning ring E steady. These plugs should be arranged four in a row on the half circle. When the first plug has passed over the end of the crankpin it should be brought to bear lightly, and when the cut is finished two should be still resting on the supporting pin F.



Turning Device

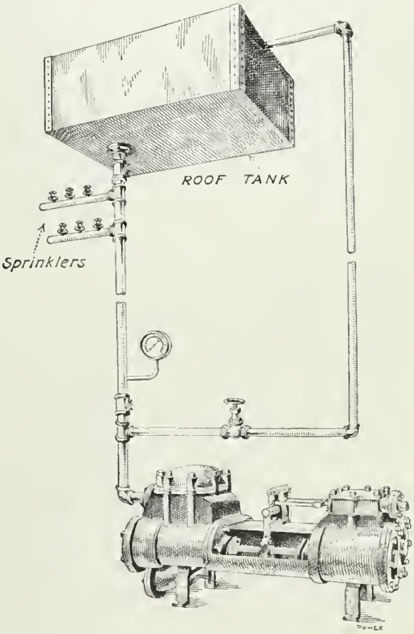
Four or six handles can be arranged on the circumference, depending on the size of the pin. The tool will have to be ground after the job is set up, on account of the peculiar angle, clearance, etc. The screw H for the feed should be a fine thread, not less than 20; 28 would be all right for a 6-in. pin, as then the hand-feed wheel C could be locked to crossbar B for the roughing cut.

N. E. Woolman.

Kittanning, Penn.

Static Pressure?

The following installation shows a condition which puzzled us for some time. Water is pumped from supply mains in the basement of a large office building to a sprinkler tank on the roof. One feed line runs from the pump to the top of the tank to fill it. The other runs from the pump to the sprinklers and to the bottom of the tank. This second line contains a check at the pump and another at the tank. The pump check was installed to prevent wasting the water in case the pump valves should not be tight. The check at the tank makes it possible to pump into the sprinklers without delivering water to the tank.



Sprinkler Piping

There is a gage in the sprinkler line which normally shows 105 lb., the pressure on the line. Imagine our surprise to see this gage pressure increase to 180 lb., with the pump standing idle, all apparently due to static pressure. We decided that the gage was at fault, and replaced it with another which showed 175 lb. Then we opened the pet-cock for drainage and the pressure returned to 105 lb., but it increased again the next day.

Knowing the height of the building had not changed, we set out to find the cause of the increased pressure. It seems that one of the steam lines ran parallel with the sprinkler riser; the water when heated by the steam expanded, and not being able to escape on account of the check valves, it boosted the pressure.

We drilled a small hole through the upper check-valve disk to relieve the pressure and still not interfere with its function. Since then we have had no trouble.

H. C. Wight.

Philadelphia, Penn.

Emergency Repair to Ash-Hoist Engine

Some years ago I was assistant engineer on a steamship plying between New York and Tampico. On our arrival at Tampico on one trip it was found that the ash-hoist engine would not work on account of broken piston rings. As getting the ashes up by "Armstrong's" method (manual labor, in other words), was a tedious job, we removed the cylinder head and piston along with the broken rings. There being no spare rings on the ship. I used a piece of hemp rope as a substitute, after soaking it in cylinder oil and graphite.

The piston after some difficulty was finally entered in the cylinder and the engine put together. It was used in this way for one and one-half trips before new rings were put in.

A. England.

New York City.

Putting in a New Crankpin

Truing out the eye and pressing in a new 11-in. crankpin on a 32¼x48-in. rolling-mill engine was done in the following way:

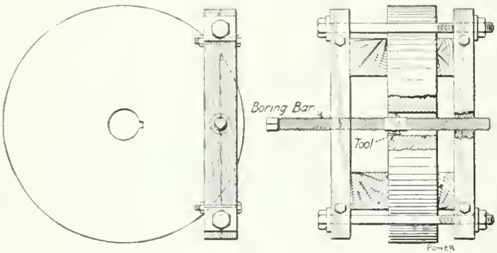


Fig. 1. Truing the Hole

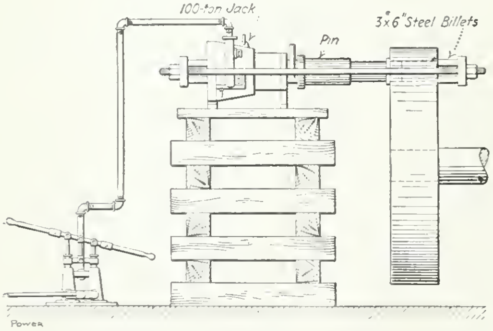


Fig. 2. Pressing in the Pin

A boring bar was made from a piece of shafting with the cutting tools fastened in a slot about midway. A fine thread (No. 16), cut nearly its entire length, acted as a feed for the tool. The bar was clamped between two 4x4-in. hardwood timbers which were in turn clamped securely to the crank disk with distance blocks between (Fig. 1). The boring bar was carefully centered in the eye and squared with the disk. Turning the bar by means of a crank operated the cutters and the feed at the same time. Several light cuts were required to true the hole.

Pressing in the pin was done with a 100-ton jack, which was supported, as shown, and clamped to the crank disk by heavy rods with two 3x6-in. steel billets set edgewise for crosstrees (Fig. 2). When about the power limit of the jack was reached a blow with a sledge on the reverse side of the disk drove the pin home.

J. C. Hawkins.

Hyattsville, Md.

Care of Manhole Gaskets

It is not uncommon to see manhole gaskets deluged with a preparation of graphite and cylinder oil before being put in place. A surplus of "dope" is the cause of many leaky manholes which sometimes means cooling the boiler to replace the gasket.

A small amount of graphite should be spread upon the side of the gasket which is to go next to the head; this is more to insure against trouble in removing the plate than for making a good joint. Flooding the side of the gasket which goes next the plate with an oily mixture is a mistake.

In such cases the gasket tends to slip off the rim. Unless the gasket is especially rigid, all added pressure from tightening will cause it to slip from the joint. Many gaskets on the market are provided with all the lubricant necessary for use. Experience has taught that a joint which will hold cold water will usually hold when hot water and steam are to be resisted. It is not advisable to pull up too tightly on the joint while it is cold. The joint should be watched while the pressure is being raised; a little drawing up may be needed when the parts become hot.

Edward T. Binns.

Philadelphia, Penn.

Surging in Discharge Pipes

In operating centrifugal pumps with jet condensers, there is at times more or less "surging." Particularly is this so if the discharge pipes are long, as in cooling towers, and they have a number of turns. As such installations generally have the end of the pipe submerged, the surging is aggravated by the pulsating water in the hot-well. It starts when the pumps are underloaded, but when once started it will continue regardless of the load.

At times not only the pipe but the pump casing springs with each pulsation.

Bracing the pipe and strengthening the pump obviates to some extent the danger, but it does not remove the cause. I have found that one way to overcome the trouble to a great extent is to have a gage on the condenser and to operate the pump only fast enough to take care of the water; in other words, regulate by the throttle according to the gage reading.

John F. Hurst.

Louisville, Ky.

Inquiries of General Interest

Material for Producer-Gas Scrubber—What kind of filtering material should be used in a scrubber tank of a gas producer using anthracite coal?

E. C. A.

Use coke in the wet scrubber and excelsior in the dry scrubber.

Effect of Animal or Vegetable Oils in Feed Water—What effect on a boiler has the presence of animal or vegetable oil in the feed water?

R. B.

Such oils contain fatty acids and upon decomposing will cause pitting, especially in places where sludgy deposits are formed in the boiler.

Longer Cutoff, Less Load—On a compound engine if the low-pressure cylinder is doing more than its share of the work, how can part of the load be shifted to the high-pressure cylinder?

D. P.

By lengthening the cutoff of the low-pressure cylinder more of the work will be done in the high-pressure cylinder. For explanation of this paradox see the article "Shorter Cutoff Greater Load," by F. R. Low, page 180, Aug. 6, 1912, issue of "Power."

Efficiency of Boiler Joint—If the strength per unit of length of a butt and double-strap joint, double riveted, is 82,500 lb., and the strength of the solid plate for the same unit of length is 100,547 lb., what would be the efficiency of the joint?

C. F.

The efficiency is the ratio of the strength of the joint to the strength of the solid plate for the same unit of length, i.e.,

$$\frac{100,547}{82,500}, \text{ or } 82 \text{ per cent.}$$

Static Electricity—What is static electricity and what would be the cause of it in a direct-current generator?

R. A.

Static (called also frictional electricity) is the electricity of stationary charges produced by rubbing together unlike bodies, such as glass and silk, in which case equal and opposite charges are always produced. In a belt-driven generator, static electricity would be caused by slippage of the belt on the pulley. The presence of static electricity is revealed by a spark or other manifestation of sudden discharge taking place when the static charge is grounded.

Coefficient of Friction—What is meant by coefficient of friction and how does the friction of solids vary?

C. R.

The coefficient of friction is the ratio of the force necessary to slide one body along another to the pressure between the bodies and varies with the character of the surfaces rubbed together. With most solids, friction, within the limit of abrasion, varies with the pressure and is independent of the extent of the surface, the time of contact or of the velocity, and when the surfaces are lubricated the friction is determined by the nature of the lubricant rather than the nature of the bodies which are rubbed together.

Methods of Superheating Steam—How is superheating of steam usually accomplished for power purposes?

C. R.

Steam is superheated by heating saturated steam, away from water to a higher temperature than its boiling point without changing the pressure, and for power purposes the saturated steam is usually heated in its passage through pipe coils (1) placed in the breeching between the boiler and chimney, or (2) placed in the boiler setting to obtain heat from the furnace gases before they leave the boiler, and sometimes before they strike the boiler, or (3) placed in an independent setting and separately fired.

Continued Running of Gasoline Engine—Why does a gasoline engine continue to run after the battery is disconnected?

J. M. D.

Continued running is usually due to expenditure of energy stored up in the flywheel. Continuance of explosions favorable to forward motion of the engine might result from ignition induced by particles of carbon or projecting parts having become heated from regular running of the engine and which had reached a temperature favorable to ignition at the time the battery was disconnected, but the combination of conditions would rarely be favorable to continue this running any length of time, preignition being likely to result.

Evaporation and Cooling—What occurs when evaporation from a surface makes it feel cooler, and why should air put in motion by a fan evaporate moisture any faster at higher velocities than at lower velocities?

J. W. D.

Up to its point of saturation, which varies with temperature and pressure, atmospheric air in contact with a liquid will absorb moisture, which is liberated from the liquid as vapor by the process of evaporation and heat, called the latent heat of evaporation, is always absorbed by a vapor in its passage from the liquid to the gaseous state. If the liquid does not receive heat as rapidly as it is absorbed in the process of evaporation, then the temperature falls and the cooling is greater as the evaporation is more rapid. Hence, with higher velocities of air set up by a fan, the cooling is greater as the increased rate at which the air is presented is accompanied by more rapid evaporation.

Noisy Exhaust Valves—How can a clattering noise of the exhaust valves of a Corliss engine be prevented?

C. G.

The noise is generally due to a valve being raised from its seat by pressure in the exhaust passages in excess of pressure in the cylinder, as when expansion in an underloaded noncondensing engine takes place below the pressure of the atmosphere. The remedy is to supply the engine with steam at lower initial pressure by reducing the boiler pressure or by throttling, so as to raise the terminal pressure. If it is impractical to reduce the initial pressure, the terminal pressure can be increased and the noise will usually be stopped by slightly opening the indicator cocks or by connecting together the indicator connections of opposite ends of the cylinder with a valve or cock between them nearly closed.

Pounding of Power Pump—What would cause pounding in a duplex power pump when used as a boiler feeder receiving water from an open heater, and how can it be remedied?

J. G. L.

Backlash or lost motion from wear of parts would cause hammering at each reversal of stroke, which could be remedied by taking up or refitting the crankshaft and connecting-rod bearings. Pounding of a piston or plunger occurs during the discharge stroke if the cylinder has not been completely filled with water during the suction stroke due to insufficiency of the suction head and sizes of suction passages for the given rate of piston displacement. Piston pounding can generally be reduced with practically no change of pumping capacity by running the pump at a slower speed or may be reduced with an increase of pumpage by lowering the pump and by increasing the sizes of the suction passages.

Measuring Cylinder Clearance—What is the best method of determining cylinder clearance of a Corliss engine?

G. W. B.

Set the engine on the center with the piston in the cylinder end where the measurement is to be taken. Remove the steam valve and fill the clearance space with water poured into the open port, drawing the water from a receptacle containing a quantity of water previously weighed or measured. When the whole space, including the port, is completely filled, the quantity remaining in the receptacle is to be weighed or measured to ascertain, by difference, the amount which has been poured into the port. Any water lost by leakage of the exhaust ports or piston, if small, may be accounted for by observing the rate of flow required to keep the port filled. At ordinary temperatures the weight of water may be taken as 0.03609 lb. per cu.in. (the weight at 62 deg. F.) The number of cubic inches of water required to fill the clearance space multiplied by 100 and divided by the piston displacement in cubic inches will be the per cent. clearance of the end of the cylinder measured.

Engineers' Study Course

Elementary Mechanics--XVI

Last Lesson's Answers

66. The force of friction will be the greatest when the normal pressure between the crosshead and the guide is a maximum. This will occur when the crank makes an angle of 90 deg. with the horizontal, as shown in Fig. 10, Lesson III, where the normal pressure is given by the line *ON*, assuming cutoff not before half-stroke.

67. (a) The motion of the crosshead is variable, as it moves first in one direction, then stops for an instant, and immediately moves in the opposite direction. Its motion might also be called *reciprocating*, since the direction of the motion changes with every stroke.

(b) The crankpin has uniform, rotary motion.

(c) A point on the rim of the flywheel has uniform, rotary motion. It might further be classified as *continuous* motion.

68. In one revolution of the engine the piston makes two strokes or moves through a distance of

$$2 \times 18 = 36\ in., or\ 3\ ft.$$

If the engine makes 250 r.p.m., the piston speed will equal $250 \times 3 = 750\ ft.\ per\ min.$

69. The velocity of the crosshead is variable, since it changes from zero, when the engine is on dead center, to a maximum, when the crank and connecting-rod are nearly at right angles, and then back to zero when the engine reaches the other dead center. The velocity of the crankpin should be uniform, especially in engines directly connected to generators, where uniform rotation is essential to constant voltage.

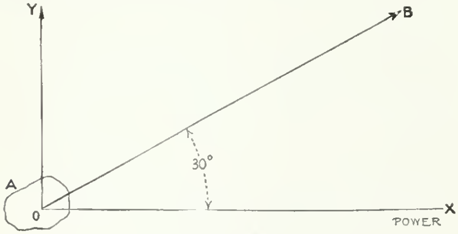


Fig. 57.

70. Four miles per hour is equivalent to

$$4 \times 5280 = 21{,}120\ ft.\ per\ hr.$$

which reduced to feet per minute is $\frac{21{,}120}{60} = 352.$

Therefore, since the fireman can walk at the rate of 352 ft. per min., it will take him $\frac{250}{352} = about\ \frac{5}{7}\ of\ a\ min.$ to cross the boiler room.

Composition and Resolution of Velocities

A velocity, like a force, may be represented graphically in magnitude and direction by a straight line, drawn to a given scale, and having an arrow-head placed at the end of the line to indicate the direction of the velocity. Thus if the line *OB* (Fig. 57) is 2 in. long, and 1 in. represents 20 ft. per sec., the body *A* will have a velocity of 40 ft. per sec. in a direction of 30 deg. to the horizontal reference line *OX*.

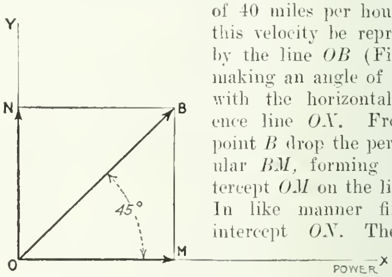


Fig. 58.

Again, as for a force, a velocity may be resolved into any number of components. For convenience in dealing with problems, velocities will be resolved into their horizontal and vertical components. Velocities acting to the right or upward will be considered as positive, and those acting to the left or downward as negative. *The component of a velocity is the rate at which the given body is traveling in the direction of the component.* As an example, assume a train traveling due northeast at the rate of 40 miles per hour. Let this velocity be represented by the line *OB* (Fig. 58), making an angle of 45 deg. with the horizontal reference line *OX*. From the point *B* drop the perpendicular *BM*, forming the intercept *OM* on the line *OX*. In like manner find the intercept *ON*. Then the line *OM* will represent the rate at which the train is traveling east, and the line *ON* will give the rate at which the train is traveling north. But

$$OM = OB \times \cos 45\ deg. = 40 \times 0.707 = 28\ miles\ per\ hour$$

Likewise

$$ON = OB \times \sin 45\ deg. = 40 \times 0.707 = 28\ miles\ per\ hour$$

which means that at the end of one hour the train will be 28 miles east of its original position and 28 miles north. During the hour it has gone 40 miles in the direction indicated by the line *OB*.

Formulas (1) and (2) given under Lesson I may be used for finding the horizontal and vertical components of a velocity.

Resultant Velocity

The resultant of two or more velocities is a single velocity that will produce the same motion of a body as the combined action of the other velocities. If the velocities are parallel and in the same direction the resultant velocity will equal the sum of the two velocities. Thus suppose the conductor of a train walks toward the forward end of the car at four miles per hour, and at the same time the train is moving at 36 miles per hour. When the conductor stands still the train carries him 36 miles per hour, but when, in addition, he walks four miles per hour, he has a velocity of 36 + 4 = 40 miles per hour relative to the earth. If the conductor walks toward the rear of the train he will have a velocity of 36 — 4 = 32 miles per hour relative to the ground.

To illustrate the method of finding the resultant of two velocities, take an overhead traveling crane in the turbine or engine room of any large power plant. Let the line OX (Fig. 59) represent the center line of the crane, and the line OY the direction the crane moves in passing down the room. Assume the crane as stationary, and suppose a workman crosses the girder of the crane at V_2 ft. per sec., or at the end of a certain number of seconds (say, T) he arrives at the point B. Again, suppose the workman stands at the point O on the crane which is now moving down the room with a velocity of V_1 ft. per sec., and at the end of T sec. arrives at the point C. Now let the workman start at the point O and walk along the girder with a velocity of V_2 ft. per sec., and at the same time let the crane move down the room with a velocity of V_1 ft. per sec. At the end of T sec. the man arrives at B on the crane, but this point, due to the velocity of the crane has been moved to D. Therefore, the man, due to the combined action of his own velocity and that of the crane, has arrived at D. If both man and crane had moved for $T/2$ sec., at the end of this time the man would be at E. It must be evident that the points D and E lie on the same straight line OD which is the diagonal of the parallelogram $OCDBO$. If another man started at the same time as the crane and walked in a direction OD with a velocity of OD ft. per sec., he would be directly under the man walking on the crane girder, overhead.

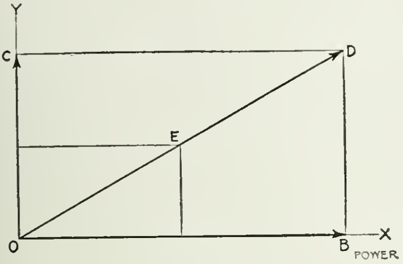


Fig. 59

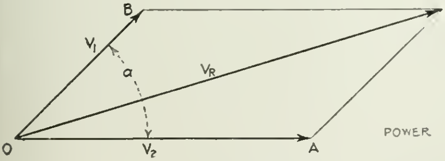


Fig. 60.

In other words, the diagonal OD represents the resultant velocity of the combined velocities V_2 and V_1. This statement could be proved equally well if the angle COB was either acute or obtuse.

From the foregoing discussion the following law known as the parallelogram of velocities may be stated. *If two velocities acting on a body at the same time can be represented in magnitude and direction by the sides of a parallelogram, the resultant velocity will be represented in magnitude and direction by the diagonal of the parallelogram drawn through the point of intersection of the two sides representing the given velocities.* Thus in Fig. 60, let the line OA represent a velocity of V_2 ft. per sec. and the line OB making an angle of a deg. with the first velocity represent a second velocity of V_1 ft. per sec. The resultant velocity will be given by the equation,

$$V_R = \sqrt{V_1^2 + V_2^2 + 2 \times V_1 \times V_2 \times \cos a} \quad (28)$$

The proof for this equation is similar to the proof of equation (5) given in Lesson II.

A body may have several simultaneous velocities not necessarily in the same plane. For example, take a body being raised by a traveling crane. At the same time the body is moving upward with a given velocity, it may also have a velocity due to the motion of the crane across the shop, and another velocity due to the motion of the trolley across the girder of the crane. The velocity of the body relative to the floor of the shop is then the resultant of three velocities.

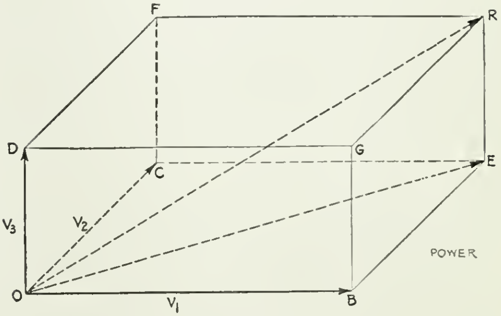


Fig. 61.

In Fig. 61 let the line OB equal the velocity V_1 with which the crane is traveling, the line OC equal the velocity V_2 with which the trolley is moving, and the line OD represent the velocity V_3 with which the body is being lifted. The diagonal OE is the resultant of the two velocities V_1 and V_2. This resultant combined with the velocity V_3 gives the final resultant velocity OR, whose value is found as follows:

$$\overline{OE}^2 = \overline{OB}^2 + \overline{BE}^2 \text{ (since angle } COB \text{ is 90 deg.)}$$

$$= \overline{OB}^2 + \overline{OC}^2 \text{ (since } BE = OC\text{)}$$

also $$\overline{OR}^2 = \overline{OE}^2 + \overline{ER}^2 \text{ (since angle } OER \text{ is 90 deg.)}$$

$$= \overline{OE}^2 + \overline{OD}^2 \text{ (since } ER = OD\text{)}$$

hence $$\overline{OR}^2 = \overline{OB}^2 + \overline{OC}^2 + \overline{OD}^2 = V_1^2 + V_2^2 + V_3^2$$

and $$OR = \sqrt{V_1^2 + V_2^2 + V_3^2} \quad (29)$$

STUDY QUESTIONS

71. The stroke of an engine is 12 in. If the engine makes 300 r.p.m., find the velocity of the crosshead when the crank makes an angle of 45 deg. with the horizontal. The length of the connecting-rod is 30 in.

72. A man rows a boat with a velocity of six miles per hour. The stream flows at two miles per hour. At what angle must the man point his boat so as to land at a point directly opposite his starting place?

73. With what velocity will he cross the stream?

74. If the stream is 1000 ft. wide, how long will it take him to row across?

75. A load is being hoisted at 200 ft. per min., by a crane which is traveling at 50 ft. per min. At the same time the trolley is crossing the crane at 75 ft. per min. Find the velocity of the load relative to the ground.

Measuring High and Low Temperatures*

By HERMANN HENRY ALBERS

It has been well said that "the history of modern industrial progress is the history of increased efficiency in production." In large technical enterprises, the highest efficiency is attained only by judicious management, coöperation, and the prudent selection of those mechanical devices designed to reduce manual labor and to obviate the human factor. Efficiency, probably more than anything else, has supplied the incentive for modern refinement in the manufacture of thermometric instruments and devices, and today there are instruments on the market which will not only measure but also record, with a high degree of accuracy, any temperature encountered in the industrial arts.

The measurement of temperature is of the utmost importance in the industries. On the one hand, certain processes and reactions occur only within a definite range of temperature, while, on the other hand, a deviation from a certain temperature may represent a loss. Progressive manufacturers and engineers in every field of production realize that temperature-controlling devices are conducive to a more uniform and better product, and are promotive of economies.

The name "thermometer," from its Greek derivatives "thermos" (heat) and "metron" (measure), suggests its use as a measure of temperature. As yet, no satisfactory definition of temperature has been given. It might be defined as a measure of the tendency for one body to transmit heat to another.

The unit of temperature measurement generally used by American engineers is the Fahrenheit degree, which may for the present be defined (in terms of the secondary standard) as equal to $^1/_{180}$ part of the apparent expansion of mercury between the point of fusion of ice and that of the ebullition of pure water under normal pressure (29.921" Hg). The Centigrade system, fast coming into general use, divides the dilatation of a column of mercury between the above mentioned points into 100 parts instead of 180, while the Réaumur scale (extensively used in the fermentation industries) employs 80 subdivisions. The Fahrenheit scale assumes the melting point of ice as 32 degrees, whereas the others take this point as 0 degrees. The following formulas may be used in transferring from one scale to another:

$$F = {}^9/_4\,R + 32 = {}^9/_5\,C + 32.$$

$$C = {}^5/_9\,(F - 32) = {}^5/_4\,R.$$

$$R = {}^4/_9\,(F - 32).$$

In order to measure temperatures, those properties of matter are utilized which are functions of the intensity of the heat to which they are subjected. Thus, lineal expansion, cubical dilatation, the thermo-electric force at the junction of two unlike metals, the electrical resistance of a conductor, the fusion points of different materials, the variable emissive power of bodies at high temperatures—all these and many other properties are employed in the design of modern thermometric instruments.

The various devices employed for measuring temperatures may thus be briefly classified according to the basic principles upon which they operate:

(1) Gas thermometers, which utilize the elastic property of the "fixed" gases.

(2) Liquid expansion thermometers, such as the ordinary mercurial instrument.

(3) Liquid pressure pyrometers, which measure the pressure exerted by confined liquids.

(4) Expansion pyrometers, which employ the unequal ratio of expansion of two different metals.

(5) Calorimetric methods, in which use is made of the known specific heats of various substances.

(6) Fusion methods, employing the melting points of different materials.

(7) Electrical pyrometers, in which either the varying resistance of a metal or the e.m.f. of a thermo-couple is measured.

(8) Thalpotasimeters, instruments utilizing the increase in vapor tension of a liquid.

(9) Optical and radiation methods, in which either the intensity of light emitted by a hot body is measured photometrically, or the total radiation (i.e., long waves which do not affect the eyes as well as the short light waves) is determined.

While the means for measuring temperatures are quite numerous, it has been found that for a specific case usually only one, or perhaps two, of the above classes serves the purpose best. Thus, the industrial engineer, employing thermometric instruments, should not only have a knowledge of the various instruments on the market, but he should also know the advantages inherent in the use of a particular apparatus. Further, many of the advantages claimed for the instruments as listed in the catalogs and expounded by salesmen, who only too often are actuated solely by a mercenary motive, are wholly illusory, and it requires the technical training and all the special knowledge an engineer may have on this subject, to discriminate between the real and these imaginary advantages. It is with this idea in mind that the writer has given a description of the various instruments, adding only enough theory to make the principle of operation more intelligible.

STANDARD THERMOMETRIC SCALE

The temperature scale has already been defined in terms of the mercury thermometer. On account of the variable coefficients of expansion of different qualities of glass, the definition of a standard thermometric scale in this manner is extremely difficult, if not impossible.

Theoretically, the thermodynamic scale devised by Lord Kelvin is ideal. Based on the principle of Carnot's cycle, temperatures measured on this scale are independent of the nature of the substance used. Thus

$$\frac{T_2}{T_1} = \frac{Q_2}{Q_1}$$

That is, the ratio of the heat absorbed to the heat rejected by an ideal heat engine is equal to the ratio of the respective absolute temperatures. This reduces the definition of temperature to the fundamental units of length, mass, and time, since Q_2 and Q_1 can be measured in terms of heat energy, which, by the laws of thermodynamics, is proportional to work. This scale, however, is unpractical and recourse must be had to some other method.

The elastic properties of gases were early recognized as a possible means of temperature measurement. The laws of Boyle and Charles, expressed mathematically in equation (1), show the relation between the volume, pressure, and temperature of a definite mass of an ideal gas. Thus

$$p\,v = m\,R\,T \tag{1}$$

in which m equals the mass of the gas, and R the gas constant, the value of $\frac{(p\ v)}{T}$ for unit mass under the temperature of melting ice.

If p_0, v_0, T_0 represent the state of m lb. of a gas at the fusion point of ice, and p, v, T any other state, then we have

$$p\,v = m\,R\,T \tag{2}$$

$$p_0\,v_0 = m\,R\,T_0 \tag{3}$$

and

$$\frac{p\,v}{p_0\,v_0} = \frac{T}{T_0} \tag{4}$$

If the volume remains constant, then

$$\frac{p}{p_0} = \frac{T}{T_0} \tag{5}$$

and, likewise, the pressure remaining constant

$$\frac{v}{v_0} = \frac{T}{T_0} \tag{6}$$

If the degree Centigrade is taken as the unit of measurement, the value of T_0 as determined by accurate experiments will be close to 273. In other words, the absolute zero of temperature is 273 degrees below the melting point of ice measured on the Centigrade scale.

Gas thermometers working upon the principles expressed by equations (5) and (6) are known, respectively as constant-volume and constant-pressure thermometers. Providing the same fixed reference points are used, the gas scale and the thermo-dynamic scale are identical.

HYDROGEN THERMOMETER THE STANDARD

Theoretically, any permanent gas may be utilized. Regnault, however, in his classic experiments on gases, found that

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*Abstract of a paper entitled "Devices and Methods for Measuring High and Low Temperatures, with Special Reference to Engineering Problems," for which the author was awarded the Stillman Prize in Applied Technology, open to competition by members of the class of 1914, Stevens Institute of Technology.

Boyle's law was not rigorously exact, and that it was, therefore, impossible to select a gas "irrespective of nature, pressure, or mode of dilatation employed." The same experimenter also determined the pressure and volume coefficients of the different gases and discovered that the pressure coefficients for H_2 N_2, and CO at constant volume were practically identical, and also that the variation of this coefficient for H at constant volume was inappreciable. For this reason the hydrogen gas thermometer was accepted as the standard and defined Oct. 15, 1887, by the International Committee on Weights and Measures as follows:

> The International Committee on Weights and Measures adopts as the standard thermometric scale for the international service of weights and measures the Centigrade scale of the hydrogen thermometer, having as fixed points the temperature of melting ice (0 deg.) and of the vapor of distilled water boiling (100 deg.) at standard atmospheric pressure, the hydrogen being taken at an initial manometric pressure of one meter of mercury—that is to say, 1000 ÷ 760 = 1.3158 times the standard atmospheric pressure.

This definition of the temperature scale is today universally accepted as the standard of reference between the interval of 0 and 100 deg. C.

[The author gives very creditable descriptions and illustrations of the principal types of thermometric instruments, which are manufactured for engineering purposes, concluding his thesis as follows:—Editor.]

SUMMARY

What is the best thermometric method? A single answer to this question, so frequently asked, is obviously impossible since the availability and choice of thermometric methods depend upon the conditions involved in particular problems. The following, however, may be taken in a general way as a criterion relative to the behavior of the more important instruments just described in respect to range, calibration and precision.

For temperatures within the interval of —30 to 400 deg. F., the mercury thermometer is recommended where conditions permit; it is cheap, accurate and simple. Where temperatures are to be controlled from some central point, or are to be recorded, the resistance thermometer presents considerable advantages. It can be used with great precision, will rapidly indicate small variations in temperature and can be employed from absolute zero to 1300 deg. F. For temperatures up to 3000 deg. F., the platinum thermocouple is quite generally accepted. The base metal couple, on account of its low initial cost, gives an instrument suitable for many thermal operations between 500 and 1300 deg. F. Where the temperature is higher than 3000 deg., or where the object operated upon is inaccessible, it being in motion, the radiation and optical pyrometers are without substitutes. The latter may be obtained in slightly more portable form and can usually be focused quicker upon the body under consideration than the radiation pyrometer, but its readings are dependent to a certain extent upon the personal factor of the observer. The radiation type is purely mechanical in operation but is generally more expensive.

In conclusion, it may be stated that there is no universal thermometer or pyrometer which can be used for all purposes. To give satisfactory results each case should be considered by itself, and the instrument employed should be adapted for the special purpose.

Pulverized Coal for Steam Making[*]

By F. R. Low[†]

SYNOPSIS—Many attempts have been made to use pulverized coal as a fuel under boilers, but few have persisted, and a small proportion of the coal used for steam making is burned in this way. The article mentions some of the earlier attempts and describes some of the systems upon which present effort is being expended. The proportionately large surface exposed by the finely comminuted fuel for oxidation makes perfect smokeless combustion with a minimum air supply possible. Combustion under such conditions results in an unsupportable furnace temperature. If this is reduced by increasing the excess air, efficiency is sacrificed; if by reducing the amount of fuel fed, capacity is limited. The overall advantage of this over the less expensive stoking methods in common use is yet to be proved.

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Numerous attempts have been made in the past quarter century to use pulverized coal as a boiler fuel. The published accounts of the various trials are full of promise and apparent accomplishment, but few of the processes have persisted, and only a small proportion of the coal used in steam making is fired in this way.

There have been three broad types of apparatus produced; that of which the Pinther (Fig. 1) is typical, where the prepared coal is emptied into a hopper above a feed-controlling mechanism and carried into the furnace by the natural draft; that having a mechanical feed, as the revolving brush of the Schwartzkopff apparatus (Fig. 2); and that in which the coal is blown into the furnace, as in the Day or Ideal apparatus (Fig. 3).

With the first type, efficiencies of from 75 to 80 per cent. were obtained, but the capacity was limited. When sufficient draft was applied to introduce a considerable amount of fuel, the velocity was such as to carry unconsumed particles of coal into the back connection and tubes. When fuel is introduced into a powdered fuel furnace at a rate which will give the full rated capacity of the boiler, a

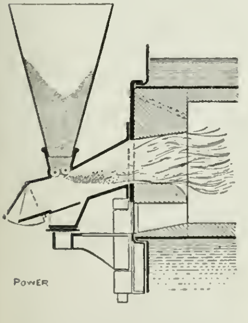

FIG. 1. PINTHER TYPE OF APPARATUS

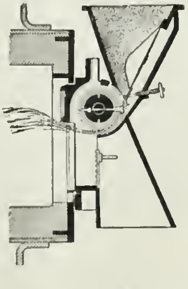

FIG. 2. SCHWARTZKOPFF APPARATUS

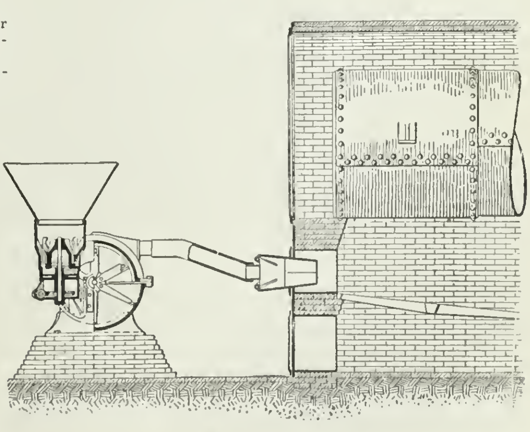

FIG. 3. DAY OR IDEAL APPARATUS

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[*] From a paper before the American Society of Mechanical Engineers at Minneapolis, Minn., June 1914.

[†] Editor of "Power."

particle will remain less than half a second in the combustion zone of an ordinary furnace.

The first installation that I ever saw for burning pulverized coal under a boiler was of the rotary brush type and was in the late nineties. The apparatus was applied to a horizontal return tubular boiler at Quincy, Mass., set in the usual way. The brush injector was placed at the furnace door and upon the grate was a thin fire composed of coal the size of hickory nuts. There was no way of feeding coal to this fire and none was necessary. Enough of the coal failed to be consumed in suspension, and fell and agglomerated itself upon the fuel bed to keep it supplied. The powdered coal in bags was dumped into the hopper above the brush. The chimney was smokeless, the fire box cloudy, but the combustion chamber full of clean white flame. The apparatus never reached the publication stage.

When it is suggested that an air blast be used to introduce the fuel, the apprehension of an excess of air is felt. The relative volumes of equal weights of coal and air are about 1:990. It would hardly be expected to use less than 15 lb. of air per pound of coal, so that the relative volumes of coal and air introduced would be

$$1 : (990 \times 15) = 1 : 14{,}850$$

The diameter of the globe of air which would accompany each tiny particle of fuel into the furnace would be $\sqrt[3]{14{,}850}$ or over twenty-four times the diameter of the particle of coal, so it will be seen that plenty of air may be used for fuel injection purposes without exceeding the supply required for complete combustion. In all of the systems at present in use, the fuel is introduced in this way, the blower usually being so combined with the pulverizer that the pulverized coal is blown into the furnace as fast as it reaches the necessary degree of fineness.

That the subject has not been neglected by inventors is evidenced by the fact that during the past 20 years there have been 23 United States patents issued for pulverized coal apparatus.

The earlier attempts to utilize pulverized coal were in connection with metallurgical processes. J. S. Dawes used it in England, in 1831, in blast furnaces, injecting it with the air through the tuyeres. It was proposed or tried in iron works by Desboissierres, in 1846, by Mouchel, in 1854, and by Mushet, in 1856. Somewhat later, Crampton tried it in locomotive and other boilers.

In 1876, Chief Engineer B. F. Isherwood, U. S. N., described* a test made by naval engineers under his direction in 1867 and 1868 at South Boston, upon an apparatus devised by James D. Whelpley and his partner, Storer, for firing a boiler in part with pulverized fuel. The boiler was of the horizontal two-flue type having only 299 sq.ft. of heating surface and 13½ sq.ft. of grate. A coal fire was maintained upon the grate and the pulverized fuel fed in above it, a fire arch being used to maintain the furnace temperature when the powdered fuel was used, but not with the grate alone.

Tests were made both with anthracite and semi-bituminous coal. The highest rates of combustion attained were 13.8 lb. per sq.ft. of grate per hour for the anthracite, and 14.9 for the bituminous, referring all the coal burned, pulverized as well as solid, to the grate area. Mr. Isherwood's conclusions were that, including the cost of pulverizing, the anthracite did a good deal better and the semi-bituminous a little better, when burned upon the grate in the ordinary way than when burned in part in the pulverized condition.

In the late nineties, D. Wegener brought out in Europe and tried in this country a natural-draft system. Tests showed boiler efficiencies of from 75 to 80 per cent. In 1910, J. E. Blake installed under a 300-hp. water-tube boiler at the Henry Phipps power plant in Pittsburgh, the arrangement shown in Fig. 4. The pulverizer served as its own blower, sending the pulverized fuel mixed with air to the furnace, where, in this installation, it was introduced by a series of nozzles extending across the width of the furnace. A little less than the rated horsepower of the boiler was obtained with an efficiency of about 79 per cent.

A later form of the Blake apparatus was installed last winter at the Peter Doelger Brewery, in New York City. The powdered coal was delivered into the top of an extension furnace or dutch oven, as shown in Fig. 5. Smokeless combustion and high efficiency were obtained, the principal trouble being from slag, which accumulated on the roof and sides of the furnace, and piled in such masses upon the floor that frequent shutdowns were required for its removal. As much water was evaporated with 1000 lb. of the pulverized as with 1400 lb. of the natural coal, but the cost of furnace maintenance, the frequent laying off of the boiler for the removal of slag and the cost of pulverizing counteracted, in the opinion of the operators, these advantages and the system was abandoned after a trial of about eight weeks.

In 1905, John B. Culliney, superintendent of the American Iron & Steel Mfg. Co., patented the controlling device shown in Fig. 6. The powdered fuel is deposited in the hopper A, filling the chamber B, when it is carried forward by the horizontal screw conveyor and dropped in a continuous stream through the chamber C. Radial rods upon the conveyor shaft agitate the mass, and push any foreign or uncomminuted material which may have been introduced with the fuel out to the sides, where swinging cover plates DD are provided for its removal. Connected to each side of the chamber C is a blast pipe E, the opening for which is shown in the longitudinal section at F. A current of air flowing through the pipe and across the falling stream of pulverized coal picks up a portion of it and carries it to the larger pipe G, where it is taken up by another air current and carried into the furnace. About one-seventh of the total air is supplied at the smaller pipe under a pressure of about 6 oz., the remainder of that necessary to complete combustion being supplied by the larger pipe under a pressure of 1½ oz. or less. The part of the coal which is not taken up by the blast is returned to the upper chamber by the inclined screw of coarser pitch, and carried forward again through the same process. Regulation of the speed of the conveying screws, and of both air supplies, gives the operator complete control of the rate of feeding and character of the flame. This system has found a wide application, not only for large metallurgical work, but for many furnaces where oil and producer gas were formerly used.

This system has been for some time in successful use for shop processes at the Schenectady works of the American Locomotive Co., and has recently been installed for steam-making purposes under a 300-hp. Franklin boiler. The arrangement is shown in Fig. 7. The results, up to this writing, have been complete smokeless combustion, no slag, several furnace linings melted down, but inability to get full boiler capacity. This is laid to limited controller capacity, and larger controllers are being installed.

Claude Bettington, of Johannesburg, South Africa, where the price of coal is high, attacked the problem by designing a boiler especially for use with pulverized fuel. He took out his first patent in the United States, but his boiler was first commercially exploited in England. In his boiler the feed is upward, as shown in Fig. 8, through a water-jacketed nozzle in the center of a vertical furnace. The pulverizer acts as a blower, and the air supply is preheated. From the pulverizer the coal passes to a separator, where the larger particles settle out and return to be again treated, the finer passing on to the burner. The blast, about 2 in., opposing gravity, tends to keep the coal in suspension, and as a particle would have to pass twice the length of the furnace (upward and downward) to escape, there is no difficulty in obtaining complete combustion.

The flame does not lift more than 10 per cent. under the highest rate of feed which it is practicable to employ, the temperature of the furnace and of the enveloping gases being increased enough to offset the greater velocity of ingress. The tubes of the inner row of the circular furnace are covered with a special refractory covering to within a short distance of the bottom header, making a brick-lined combustion chamber. The special bricks are placed loosely around the tubes, but soon become coated with molten ash and slag, which welds them into a solid wall, and closes the crevices between the lining and the top header. The ash which is not so slagged to the furnace surfaces, or carried out by the draft, drips into the ashpit below the lower header. The destructive effect of the impinging flame upon the brickwork is avoided by taking it upon the lower head of the central drum, or upon the accumulation of gas in the upper end of the chamber, the region of greatest heat intensity being in the core, while the tubes and shell are subjected to the lesser temperature of the somewhat cooled gases, which have not yet got away. The radiant heat is, however, effective upon them and the metal surfaces must be kept clean, and particular care taken to maintain a safe water level. One of these boilers having 2606 sq.ft. of heating surface has been running for over four years at the works of the builders. It evaporates regularly 14,000, and has been worked up to 22,000 lb. of water per hour. These rates, however (5.4 and 8.4 lb. per sq.ft. of heating surface) are attained with stoker fired boilers.

A contributor to "Power" who has had two of these boilers in charge says* that the steel head of the upper drum

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*Engineering and Mining Journal.

*"Power," May 12, 1914, page 678.

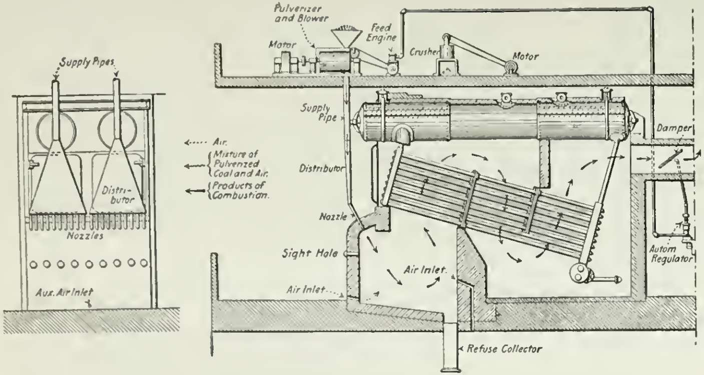


Fig. 4 Blake and Phipps Installation

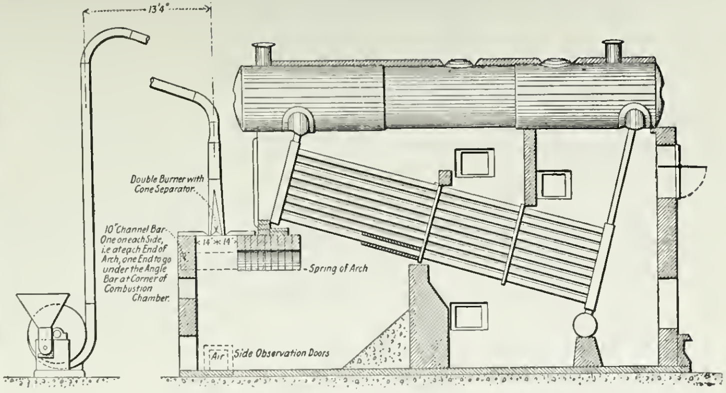
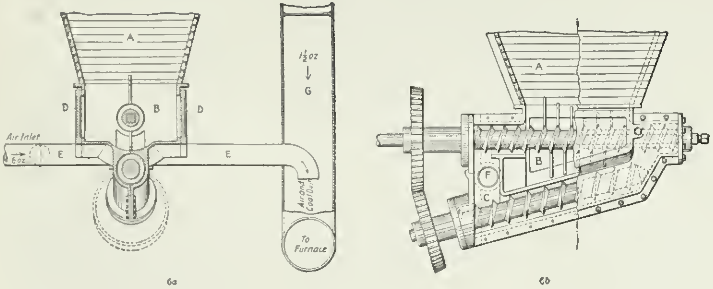

13'4"
Double Burner with Cone Separator.
10" Channel Bar-One on each Side, i.e. at each End of Arch, one End to go under the Angle Bar at Corner of Combustion Chamber.
14"×14"
Spring of Arch
Air
Side Observation Doors

Fig. 5 Doelger Installation



6a

6b

Figs. 6a and 6b Cullney Feeding

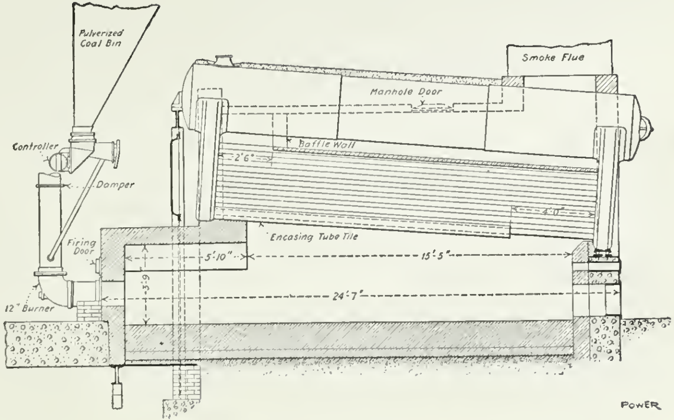


Fig. 7 300-H.P. Franklin Boiler, American Locomotive Company burned through at one time, probably due to dirt collecting upon it; that in spite of the cooling effect of the tubes the special bricks forming the furnace quickly burn away. Care must be taken lest the lining burn through and the gasses be short-circuited. Although this boiler will burn low-grade fuel successfully, and while under steam is easily managed, one fireman being able to look after several boilers, these advantages are largely offset in his opinion by high maintenance charges.

The makers say their experience has been that a lining will last about two years, and that even large holes will automatically seal up. The parts which require most frequent renewal are the beaters and liners of the pulverizer. These are of manganese steel, and can be replaced in about two hours. The approximate life for the beaters is 1500, and for the liners, 2000 tons of coal handled. A user, after 10 months' experience, says that the blades run from 1000 to 1200 hours per set, and that the second set of liners was still in use. The use of heated air in the pulverizer allows coal having 15 per cent. or more of moisture to be handled successfully; a separate heater is recommended for large boilers. Two to 3 per cent. of the boiler capacity is allowed for pulverizing. There was some trouble from leaky water jackets putting the flame out, but this has been overcome by the use of welded jackets.

Tests of one of these boilers showed an efficiency of 82.6 per cent., the coal having 2.15 moisture, 22.8 volatile, 57.55 fixed carbon, 17.5 ash. The CO_2 is carried at 15 per cent. in regular practice.

With the ordinary method of burning coal, the grate with its bed of solid incandescent fuel more or less encumbered with ash and clinker, offers a considerable, a varying, and an uneven resistance to the passage of air, rejects the incombustible residuum with some difficulty and allows some of the unburned fuel to sift to the ashpit or to be fused with the clinker. If the fuel can be burned in suspension, many of these difficulties disappear and the draft-producing apparatus is reduced to that which will remove the products of combustion and allow enough air to enter to burn the required amount of fuel. There still remains, however, the difficulty of getting rid of the incombustible. With 10 per cent. ash there will be 200 lb. of refuse to be got rid of with each ton of coal burned. If this is kept in a pulverized form it is carried into the back connection, the tubes and stack, and scattered about the neighborhood. If it is fused it attaches itself to the surfaces of the furnace and welds itself into masses, occasioning damage to the brickwork in its removal and comparatively frequent layoffs for cleaning. In one instance, the molten slag formed in sheets and ridges upon the sides and in stalactites upon the roof of the furnace, while the floor was covered with a plastic mass, which cooled when the door was opened for its removal, and could hardly be got out without material damage to the furnace.

The possibility of getting an adequate supply of oxygen to the finely comminuted carbon allows perfect and smokeless combustion with a minimum air supply, but with rates of combustion demanded in present practice, the result is a high temperature with erosive and reducing characteristics which, however good they may be for metallurgical processes, are not favorable to the longevity of a boiler furnace. If this temperature is kept down by feeding less fuel, the capacity is limited, while if kept down by using an excess of air the economic advantage is sacrificed.

There have been several disastrous explosions of the prepared fuel outside of the furnace, but these can be easily guarded against. Coal, however finely comminuted, does not contain the elements necessary for its own combustion, and if ignited will burn slowly if kept in a compact mass. It is only when it is diffused in a cloud that the oxygen of the atmosphere can get to it quickly enough to make the rate of combustion dangerous. The pulverized fuel can be safely conveyed en masse in suitable holders, in screw conveyors, or in cars and barrows if care is taken that it shall not be blown or sifted about in a finely disseminated state. In those systems where the pipe back of the blower is filled with an explosive mixture of coal and air, the rate of flow must exceed that of the propagation of flame in such a mixture, and in shutting down, the coal supply should be shut off first. The pulverized mass will run like water, so that the pitch of chutes, conveyors, etc., must be so set as to provide against the flowing of their contents.

While anthracite dust can be used it burns more slowly than coal higher in volatiles, and must be very finely pulverized. For most systems practically all of the coal should go through a screen having 100 meshes to the inch, and for coals having a small percentage of volatile or where very rapid combustion is imperative, the coal is ground to a fineness which will permit the greater part of it to pass through a 200-to-the-inch sieve. Low-grade coals and coals having a large percentage of ash can be burned in this way, but there is a limit to the proportion of slate and bone that one can afford to grind, and an increasing proportion of ash means increased trouble from dust and slag.

The earlier practice of taking up the impingement of the flame on a checkerwork or a heap of brickbats is out of favor. It simplifies the process of keeping the burner lighted, but burns too much firebrick and makes a locus for the building of a slag heap. With an ordinary firebrick furnace well heated up there is no trouble in maintaining the flame steady, and it will reignite after having been turned out for several minutes.

The cost of pulverizing and the large initial cost of the drying, pulverizing, conveying and feeding apparatus, together with the fact that coal of practically all grades can be burned with a tolerable degree of smokelessness in the cheaper apparatus in common use with a degree of efficiency which leaves little margin to cover the increased expenditure, have combined to restrict the use of pulverized coal for boiler purposes.

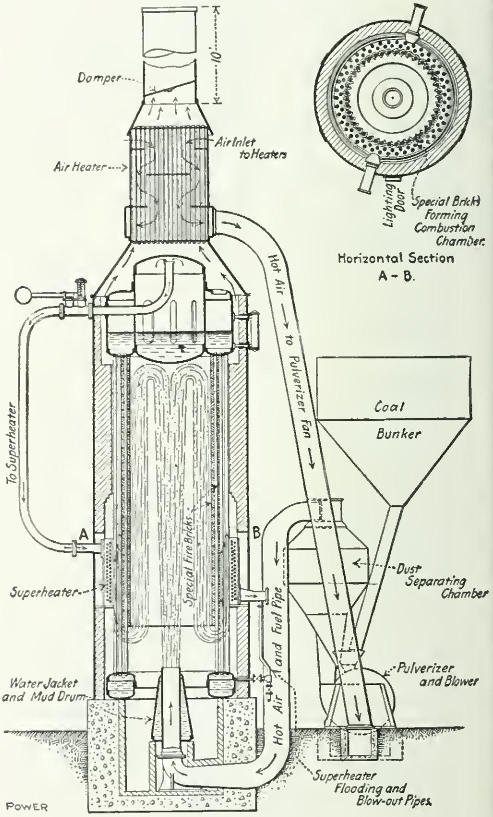


Fig. 8. Bettington Boiler

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Brotherhood of Boilermakers' Convention—One hundred and twenty-five delegates from various parts of the country attended the eleventh biennial convention of the International Brotherhood of Boilermakers, Iron Ship Builders and Helpers, which began at San Francisco on June 9.

*

Westinghouse Elects Directors—On June 10 the Westinghouse Electric & Manufacturing Co. elected the following directors at the East Pittsburgh plant: A. G. Becker, Wm. McConway, John R. McCune, George M. Verity, Paul M. Warburg, H. H. Westinghouse, P. D. Cravath and J. N. Wallace.

Temperatures in Electrical Apparatus*

Electrical apparatus is unfortunate in the use, as an important material of construction, of cotton, paper and similar fibrous materials having a weak mechanical structure and subject to deterioration at relatively low temperatures. The general use of these materials in electrical apparatus has justly placed on it the handicap of low operating temperatures and has emphasized the important relation between operating temperature and safe capacity and length of life.

The temperature conditions existing in a large alternator armature core and winding are illustrated in Figs. 1 to 3, the first representing a cross-section of a coil in the end windings surrounded by air on the four sides. The curve shows the temperatures existing along the line. The temperature of the copper, a — c, is shown to be 70 degrees C., with a slight drop toward the surface. A drop of about 30 degrees is shown through the coil insulation and there is a further drop of 20 degrees from the surface of the insulation to the surrounding air.

It is difficult to measure the surface temperature by a mercury thermometer without changing the heat resistanc of the circuit and thus changing the temperature being measured. As surface temperatures are ordinarily measured, a mercury thermometer is placed in contact with the surface and the thermometer is covered by an insulating pad; the effect of this pad is shown in Fig. 2. The copper temperature may be increased, more heat flows through the insulation on the uncovered side of the coil (resulting in the larger drop shown) and a still greater part of the heat flows through the paths of less resistance adjacent to the covered part of the coil. Very little heat flows through the path, including the thermometer pad, with the result that the temperature drop through the insulation is greatly reduced and the thermometer indicates a temperature nearer the true copper temperature than the true surface temperatures.

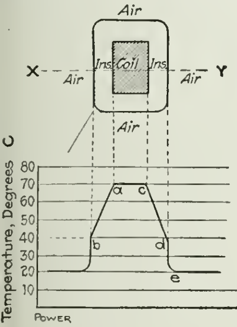

Fig. 1. Temperature Diagram of Armature Coil in Air

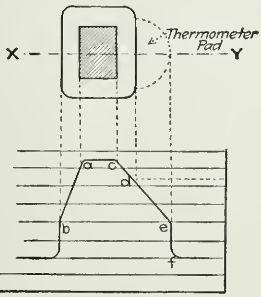

Fig. 2. Temperature Diagram of Armature Coil in Air with Thermometer Pad

Fig. 3 illustrates the temperature drops and direction of heat flow within the core through the center of the slot along the line YY. It has been assumed that the load and design are such that the copper temperature is higher than that of the core, so that the heat flows from the copper to the core. The highest temperature is shown in the center of the coil nearest the air gap. The loss in this coil is often greater than in the coil beneath it, due to the penetration of the air-gap flux within the top of the slot. On the other hand, the heat flow from the top coil is sometimes greater, due to the greater conductivity of the path passing through the wedge to the air.

But little heat flows through the insulation between the coils, since they are at nearly the same temperature. There is a very large flow of heat from the slot and tooth belt through the core to the outer core surface which produces the large temperature drop shown, in spite of the relatively low heat resistance of the sheet steel.

In Fig. 4 is shown the temperature drop along the longitudinal path from the part of the coil in the center of the core, along the copper, and through the end insulation to the air.

LIMITING TEMPERATURES OF INSULATING MATERIALS

Insulating materials in common use for coils may be conveniently grouped in two classes from the standpoint of temperature:

1. Cotton, silk, paper and other fibrous materials.
2. Mica, asbestos and similar heat-resisting materials.

Obviously, the fibrous materials have a much lower limiting temperature than those in the second class. However, the materials in that class are usually used for armature coil insulation, with those of the first-class serving as a means of mechanical support for the main insulation. In this connection it may be mentioned that machine-wrapped mica insulation will operate satisfactorily at higher temperatures than hand-wrapped.

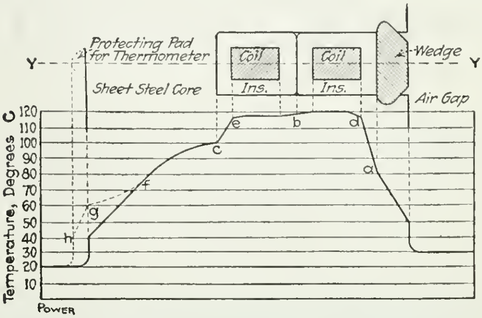

Fig. 3. Temperature Diagram of Armature Coils and Core (in Direction of Laminations)

The temperature limit of pure mica or asbestos is so high that when either is used alone, as is often the case in turbo-field insulation, and sometimes in armature-coil insulation, the temperature limit is imposed by other parts of the apparatus than the insulation.

While experience with mica and paper (combined) insulation has shown that it can safely withstand such temperatures as 200 or 300 degrees, these high temperatures are not advocated for generators of normal design. The following gives a conservative limit for the different insulating materials:

	Kind of Insulation	Temperature Limit	Remarks
(1)	Treated cotton, paper, silk and similar fibrous materials.	105 deg.	This limit is well established and probably will not be increased by future experience except under conditions of low voltage and rigid support.
(2)	Mica, asbestos and similar refractory materials, used without lower temperature materials, as in some turbo-generator field windings.	No limit	The temperature limit is so high that meterials or conditions other than insulation impose the limit.
(3)	Combinations of (1) and (2) in which both classes of materials are necessary for insulation strength.	105 to 125 deg.	The limit in a particular case depends on the relative proportions of the two classes of materials and on the application.
(4)	Combinations of (1) and (2) in which materials of the first class are used for structural purposes only and are not depended on for insulation strength.	150 deg.	Experience has defined this limit less rigidly than in the other classes. Future experience will undoubtedly justify raising this figure.

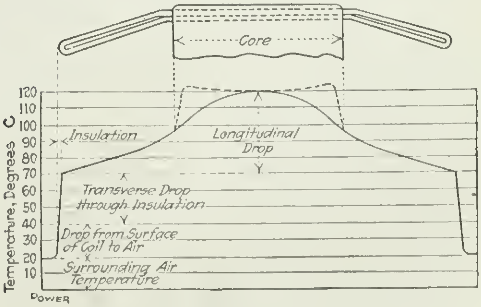

Fig. 4. Longitudinal Temperature Diagram of Armature Coil

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*Abstract from a paper by F. D. Newbury before the National Electric Light Association.

TEMPERATURE MEASUREMENTS

Measurements by means of mercury thermometers show the surface temperatures, which are less than the nearest heat source, by a drop which is partly determined by the covering applied outside the thermometer.

Temperature measurements by increase in the resistance of the winding itself give average temperatures which are higher than those at the surface unless the drop through the insulation is negligible or the hottest part of the heat source is accessible to the mercury thermometers.

Much higher results than either of the foregoing are obtained by means of thermo-couples which record approximately the hottest temperature of the heat source.

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Boilermakers National Convention—The International Brotherhood of Boiler Makers, Iron Shipbuilders and Helpers of America, in 11th biennial convention, elected the following officers at San Francisco, Calif., on June 20: International president, J. A. Franklin, Kansas City, Kan.; first vice-president, A. Hinzman, Kansas City; second vice-president, Thomas Nolan, Portsmouth, Va.; third vice-president, J. P. Marrigan, Montreal, Canada; fourth vice-president, Louis Weyand, Cleveland, Ohio; fifth vice-president, John P. Down, New York; sixth vice-president, William Atkinson, Los Angeles; seventh vice-president, M. A. Maher, Portsmouth, Va.; eighth vice-president, Joseph P. Ryan, Chicago; ninth vice-president, John F. Schmitt, Columbus, Ohio; secretary-treasurer, Frank R. Einemeyer, Chicago; editor of "Journal," James B. Casey, Kansas City.

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Careless Firemen—A careless or ignorant fireman will often throw into a furnace twice as much coal as is needed, usually piling it near the front of the grate while the sides and edges are relatively thin. By leaving holes in the fire bed or allowing the firing doors to remain open unnecessarily, he admits excess air into the furnace which reduces the temperature of the flue gases.

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"The Engineering Manual," published by the American Electric Railway Engineering Association is now being distributed. This publication is a compilation of the standards and recommendations adopted by this association and covers practically the entire field of electric railway engineering. The book is in loose-leaf form, and has 82 sections, fully illustrated with diagrams and working drawings. The loose-leaf form was adopted so that the standards and recommendations may keep pace with such additions and alterations as are made at the yearly conventions of the associations. Separate sections may be obtained. The price to nonmembers of the association is $3, and binders $1 extra. Members will receive the manual (without binder) free.

Pennsylvania State Convention

Probably the largest and most successful convention of the Pennsylvania State Association of the N. A. S. E. was held in Philadelphia, on June 19 and 20. The Vendig Hotel was the headquarters. The attendance of delegates was exceptionally large.

The business sessions took place in the Parkway Building, next door to the headquarters hotel. The exhibition hall was also in the Parkway, and provided plenty of light, with ample space for the exhibits.

On Friday morning at ten o'clock Peter O. Johnson, chairman of the convention committee, opened the convention for the preliminary exercises. After a few words of welcome to the city officials who were present, Mr. Johnson introduced the Hon. George D. Porter, director of public safety, who spoke warmly of Philadelphia and its environments, and extended to the delegates and guests a hearty welcome.

Samuel B. Forse, national treasurer of the N. A. S. E., responded in suitable terms for the engineers.

National President James R. Coe, whose name was not on the program, and appeared as a pleasant surprise, was then introduced, and spoke interestingly of the progress of the N. A. S. E.

AT THE PENNSYLVANIA STATE CONVENTION, N. A. S. E., PHILADELPHIA, JUNE 19-20, 1914

The convention then went into executive session, and after the various committees were appointed the meeting adjourned until 2 p.m.

The entertainment program included an afternoon automobile trip for the ladies about the city and suburbs, paying a visit to College Inn, where a sumptuous chicken dinner was served, the company returning to the hotel at seven o'clock.

Promptly at 8:30, in the large auditorium of the Parkway Building, the entertainment given by the supplymen took place. A most enjoyable evening was furnished by the following: Hart and Neal, Monroe Silver, Pauline Lorraine, Brendel and Morgan, Pauline Newman, and the Musical Ogdens, of the supplymen, and Herbert Self, Peerless Rubber Manufacturing Co.; Joseph Hickey, Keystone Lubricating Co.; Andrew McHugh and Joe McKenna, Jenkins Bros., and Jack Armour, of "Power"; Bob Nolan was at the piano.

The entertainment features wound up with a smoker on Friday night.

At the final meeting of the delegates the following state officers for the ensuing year were elected:

President, James D. Rostron, Chester; vice-president, Peter O. Johnson, Philadelphia; secretary, R. B. Ambrose, Pittsburgh; treasurer, D. E. Seeley, Du Bois; conductor, C. W. Leitenberger, Johnstown; doorkeeper, Earnest Uff, Chester.

THE EXHIBITION

The following firms had representatives in attendance:

Albany Lubricating Co.
American Bitumastic Enamels Co.
Magarvey & Griffith
Morris Metallic Packing Co.
McArdle & Cooney

Ames Iron Works
Anchor Packing Co.
Barnett Manufacturing Co.
Bell Coal Co.
Bird-Archer Co.
Bond Co., Charles
Borgner Co., Cyrus
Budd Grate & Foundry Co.
Dearborn Chemical Co.
Dixon Crucible Co., Jos.
Durabla Manufacturing Co.
Fairbanks Co.
Ford & Kendig Co.
Frick Grate Bar Co.
Garlock Packing Co.
Goodall Rubber Co.
Greene, Tweed & Co.
Griscom-Russell Co.
McClave-Brooks Co.
National Ammonia Co. of Pennsylvania
National Flue Cleaner Co.
National Supply & Equipment Co.
Newton Coal Co., George B.
Nazel Engine & Machine Works
Parkesburg Iron Co.
Peerless Rubber Manufacturing Co.
Philadelphia Grease Manufacturing Co.
"Power"
Quaker City Rubber Co.
Robinson & Son Co., Wm. C.
Roebling's Sons Co., John A.
Harrison Safety Boiler Works
Home Rubber Co.
Homestead Valve Manufacturing Co.
Houghton & Co., E. F.
Jenkins Bros.
Johns-Manville Co., H. W.
Keystone Lubricating Co.
Kruger & Blind Co.
Lagonda Manufacturing Co.
Livezey, John R.
Lunkenheimer Co.
Rooksby & Co., E. J.
Strong, Carlisle & Hammond Co.
Underwood & Co., H. B.
United States Graphite Co.
Vacuum Oil Co.
Watson & McDaniel Co.
Walsh Packing Co.
Webster & Co., Warren
Westinghouse Electric & Manufacturing Co.
Williamson & Cassedy

We regret that we were unable to secure a photograph of the delegates and guests in time for publication.

The next meeting will be held at Pittsburgh, June 18 and 19.

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Annual Meeting of American Institute of Electrical Engineers

The thirty-first annual convention of the American Institute of Electrical Engineers, at Detroit, on June 22 to 26, although not as large in attendance as some former meetings, ranked well in the character of its technical sessions and in its enjoyment of the opportunities offered by that city for entertainment and inspection trips.

With headquarters at the Hotel Ponchartrain, the convention began with a reception and dance on Monday evening.

PRESIDENT'S ADDRESS

On Tuesday morning President C. O. Mailloux opened the technical sessions with an address on "The Evolution of the Institute and Its Members." As one of its charter members, he reviewed the phenomenal growth of the Institute and pointed out that, although one of the youngest of the national engineering societies, it has now taken a place in the front rank. Much of this success had been due to the untiring work of the committees and the active members who have gratuitously rendered service, which money could not hope to buy.

Due to the ever-increasing scope of electrical engineering, new specialties have sprung up, some of which have assumed sufficient importance in the number of persons interested and the technical work done to warrant separate associations such as the Electro-Chemical and the Illuminating Engineering societies. While the formation of these two had been justified, in Mr. Mailloux's opinion, it was not wise to subdivide a large field into too many independent societies. He believed the whole field of electrical engineering could be served best by the parent society, comparing it to a central station with a high diversity factor.

Mr. Mailloux concluded his address with a plea that engineers as a class should take a greater interest in civic affairs. "Our neglect," said he, "to occupy the place that belongs to us is a serious handicap to the prestige and influence of our professional class, and places it in a condition of relative disparity before the world as compared with other professions such as law, medicine and fine arts. * * * Only in exceptional cases do we see engineers vested with the authority which gives the final decision; indeed, they are never in a majority in a deciding body."

D. B. Rushmore indorsed the president's remarks and added that in public-service commissions the engineers are often consulted on important matters, but occupying a subordinate position, have no voice in the final decisions. This condition he believed was partly because their training was along specialized lines and partly because the average engineer is not a highly trained executive.

ELECTRICITY IN MARINE WORK

The first paper of the morning was "Electric Heating as Applied to Marine Service," by C. S. McDowell and D. M. Mahood. Among the advantages pointed out were simplicity and low cost of installation, saving in weight, freedom from leaks, noises and disagreeable odors as compared to steam, and ease of regulation. Attention was called to its use for first and second cabins on some of the latest Atlantic liners.

"The Electrically Driven Gyroscope in Marine Work," by H. C. Ford, was the next paper. The gyro-compass, said the author, makes use of the earth's daily rotation and consequent changing direction of gravity to secure a directive force a hundredfold greater and more accurate than that of the magnetic compass. This type of compass as adopted by the United States Navy was described. While large gyroscopes are made capable of stabilizing any ship against rolling in the heaviest seas, one of its principal applications promises to be in aëroplane work.

INDUSTRIAL POWER

The industrial power session was held Tuesday evening and consisted of three papers: "Direct-Current Motors for Coal and Ore Bridges," by R. H. McLain; "Methods of Keeping Down Peaks on Power Purchased on a Peak Basis," by T. E. Tynes, and "Concatenated Induction Motors for Rolling Mill Drive," by William Oschmann.

Mr. McLain described the mechanical arrangement of a coal bridge, consisting essentially of a trolley car with hoisting mechanism for a self-filling bucket. A series motor was recommended for driving the trolley car and for a slow-speed hoist, whereas a shunt motor is best for a high-speed hoist. The relative merits of both types were discussed.

The method described by Mr. Tynes for keeping down peaks on the purchased power was as follows: Exhaust steam being available from pumps, air compressors, etc., a low-pressure turbine was installed to handle the peaks. This is kept running light on the line and by means of a special contact attached to the maximum-demand meter, relay circuits are closed and operated to short-circuit sections of resistance in the field rheostat of the turbo-generator. This raises its voltage and causes it to take the peak load. Conversely, when the demand goes off, the resistance is cut in on the rheostat and the voltage of the machine is lowered, thus reducing its load.

Mr. Oschmann's paper described a six-speed concatenated induction motor set for driving the finishing rolls of a 12-stand mill. It consisted of a double-wound main motor and single-wound secondary motor, both stators mounted on a common bedplate, and both rotors on a common shaft. The larger motor has both a 14- and a 16-pole stator winding and the secondary motor has its winding arranged for four- and eight-pole connections. The motor has six definite speeds and two additional resistance speeds, and the control is such that no regular attendant is required.

Following this paper, moving pictures were thrown on the screen showing the operations in the mills of the National Tube Co., from ore to finished pipe.

ELECTROPHYSICS

Wednesday morning was devoted to a session on electrophysics, three papers being presented: "The Sphere Gap as a Means of Measuring High Voltage," by F. W. Peek, Jr.; "The Electric Strength of Air," by J. B. Whitehead and W. S. Gorton, and "Sphere-Gap Discharge Voltage at High Frequencies," by J. C. Clark and H. J. Ryan.

ENGINEERING DATA

Two reports were rendered on Thursday morning by the committee on engineering data. The first, which was presented by Chairman Percy H. Thomas, represented the practice of twenty-five power companies operating at 25,000 volts or over. Full particulars on the transmission-line constructions, as well as operating features, were given. Owing to its importance an abstract of this report will appear in a subsequent issue.

The second report of the committee dealt with "Specifications for the Inspection and Tests of High-Tension Line Insulators."

PRIME MOVERS

Thursday afternoon, H. G. Stott read the committee's report on prime movers in which reciprocating steam engines, steam turbines, gas engines, oil engines and hydraulic turbines were compared as to relative importance, capacity, efficiency, weight, cost and economy.

During the past five years the reciprocating steam engine, said Mr. Stott, has become practically obsolete for use in modern power stations. It is still used in isolated plants where exhaust steam is used for heating, and in this service has some advantage over the small turbine, although the margin is continually becoming smaller.

He quoted figures to show that the large steam turbine has now passed the gas engine in thermal efficiency, the only prime mover now surpassing it being the Diesel engine, which has a maximum operating efficiency of about 28 per cent. compared with 24 per cent. for the latest 20,000-kw. high-vacuum steam turbines. The data and curves from this report will appear in a later issue.

Following Mr. Stott's report was a paper on "Voltage Testing of Cables," by W. I. Middleton and C. L. Dawes.

Charles F. Brush, of arclight fame, was the recipient of the Edison Medal on Thursday evening, at which time the past-president's badges were also presented. President-elect Paul M. Lincoln was introduced and made a short address.

ELECTRO-CHEMICAL SESSION

Friday morning was devoted to three papers, "Sterilization of Water by Ultra Violet Rays," by M. von Recklinghausen; "Toll Telephone Traffic," by Frank F. Fowle, and "A High-Speed Printing Telegraph System," by Carl Kinsley.

This was followed by a conference of section delegates and officers.

ENTERTAINMENT

The entertainment features consisted of automobile trips about the city, a boat ride to Bois Blanc Island, inspection trips to the Ford plant and the stations of the Detroit Edison Co., a dance and cabaret on Thursday evening, a card party for the ladies, and tennis and golf tournaments for which handsome trophies were awarded.

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Ohio State N. A. S. E. Convention

The annual convention of the Ohio State N. A. S. E. took place at Akron on June 17 to 19, with an excellent attendance, the delegates convening at 9:30 Wednesday morning in East Market Street Rink.

After the opening ode "America" and the invocation by the Rev. L. N. D. Wells, Mayor F. W. Rockwell welcomed the delegates, W. E. Lewis, of Massillon, No. 14, responding.

President F. A. Seiberling, of the Goodyear Tire & Rubber Co., and a former president of the Akron Chamber of Commerce, delivered a most interesting address on "Akron—Its Manufactures." State President J. E. Radigan made an appropriate response. The morning session closed by singing the "Red, White and Blue" and with prayer by the Rev. Mr. Wells.

The afternoon session began at 1:30 o'clock.

In the evening, at eight o'clock, the exhibition was formally opened. A male chorus of 36 under the direction of Prof. Griffith, and vocal and instrumental solos furnished the music.

On Thursday morning, after a short business session the Northern Ohio Traction Co. provided special cars for all to visit the Gorge power house. The party was then taken on flat cars to the hydro-electric plant a mile down stream. All the delegates took part in strenuous reducing exercises and climbed the 175 steps back to the cars.

The B. F. Goodrich Co. plant was next visited. Guides were provided and the visitors were divided into squads and conducted through a large part of the 75 acres of floor space. They were shown everything from the grinding and compounding of the rubber to the finished products, including auto tires, hose, belting, valves, boats, insulated wire and products of rubber in every shape and description.

The trip ended at the company's offices where refreshments were served and souvenirs were distributed, including small hot-water bottles for the ladies and watch fobs for the men.

The traction company then transported all the delegates to the Goodyear Tire & Rubber Co. Here again Akron hospitality was shown at its best. Guides were provided and a hurried trip was taken, beginning at the power plant, thence through the various rooms. The Goodyear Co. served supper to all in the company dining rooms. The way six people served the crowd with such efficiency was a marvel to the visitors.

The committee of arrangements deserves especial mention for the fine program of Wednesday evening—to say nothing of the concert conducted by "Prof." Raven, N. A. S. E., Thursday evening.

Dayton, Ohio, was chosen for the next meeting place.

EXHIBITORS

Akron Metallic Gasket Co.
H. W. Johns-Manville Co.
C. E. Squires Co.
Factory Oil Co.
Ohio Injector Oil Co.
Leavitt Machine Co.
Griscom-Russell Co.
Goodyear Tire & Rubber Co.
"National Engineer"
"Power"
William Powell Co.
Bowers Rubber Works
Trill Indicator
Peerless Rubber Manufacturing Co.
Dearborn Chemical Co.
Burt Manufacturing Co.
B. F. Goodrich Co.
Lagonda Manufacturing Co.
Arrow Boiler Co.
Jenkins Bros.
Greene, Tweed & Co.
American Steam Gauge & Valve Manufacturing Co.
Cling-Surface Co.
Keystone Lubricating Co.
Howe Rubber Co.
V. D. Anderson Co.
White Star Refining Co.
Perolin Co. of America
Garlock Packing Co.
Hawk-Eye Compound Co.
H. Mueller Co.
Crandall Packing Co.
Hill, Hubbell & Co.

A GROUP AT THE OHIO N. A. S. E. STA

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Indiana State N. A. S. E. Convention

On June 10 to 12, Indiana engineers held their tenth annual convention at the Hotel Severin, Indianapolis. Discussion on a state license law and the formation of chapters at Fort Wayne, and Hammond were the features of the business sessions.

On Wednesday evening there was a smoker in the exhibit hall, following a lecture by Mr. McMeans on "Practical Engineering."

On Friday afternoon the engineers visited the storage-battery plant of the Indianapolis Light & Heat Co., and in the evening attended a chicken supper at Broad Ripple Park.

Richmond was selected as the convention city for 1915. The following officers were elected: Louis Minke, Evansville, president; Albert Franke, Terre Haute, vice-president; Ignatz Baldus, Indianapolis, secretary; Albert T. Arens, South Bend, treasurer; W. E. Mutchnes, Richmond, conductor; Elza Scott, Kokomo, doorkeeper; E. G. Huger, Evansville, state deputy.

Following is a list of the exhibitors:

Greene, Tweed & Co.
"National Engineer."
"Power."
The Garlock Packing Co.
American Steam Gauge & Valve Mfg. Co.
Indianapolis Belting & Supply Co.
Dean Bros. Steam Pump Wks.
Crane Co.
Griscom-Russell Co.
Hide, Leather & Belting Co.

Hawk-Eye Compound Co.
The V. D. Anderson Co.
Dearborn Chemical Co
Home Rubber Co.
The Lunkenheimer Co.
White Star Refining Co.
H. Mueller Co.
Wm. Powell Co.
Jenkins Bros.
H. W. Johns-Manville Co.
The Perolin Co. of America
Crandall Packing Co.
Keystone Lubricating Co.
Henry Vogt Machine Co.
Central Supply Co.
Central Rubber & Supply Co.
Crescent Oil Co.
Indian Refining Co.
Quaker City Rubber Co.
Trill Indicator Co.
Open Coil Heater & Purifier Co.
Home Brewery
Standard Oil Co.
Vonnegut Machinery Co.
Chandler & Taylor Co.
Arrow Boiler Compound Co.
Hetherington & Berner.
Indianapolis Electric Supply Co.
Garrett-Callahan Co.

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Connecticut N. A. S. E. Convention

The nineteenth annual convention of the Connecticut State Association of the N. A. S. E. was held at Bridgeport, Conn., on June 26 and 27, with headquarters at the Stratfield Hotel.

The preliminary ceremonies took place at Friday noon, Frank J. Quinlan, chairman of the local committee, presiding. After a short address Mr. Quinlan introduced the Hon. Clifford B. Wilson, mayor of Bridgeport, who spoke of the city's large large commercial interests and of its national attractiveness. He warmly welcomed the engineers and guests. James R. Coe, national president, replied for the engineers, and paid a tribute to the supplymen for the support they have always given to the engineers in their business and social dealings with the N. A. S. E. Bernard J. Reynolds, state president, then addressed the meeting. Mr. Quinlan formally opened the supplymen's exhibition, after which the delegates went into executive session.

VENTION AT AKRON, OHIO, JUNE 17 TO 19, 1914

The meetings of the delegates were held in a hall in the Eagles' Building, and in the large Auditorium adjoining the supplymen had their mechanical display.

On Friday evening a smoker was held at which a most enjoyable entertainment was given, and refreshments of all kinds were served. Auto trips through the city were enjoyed by the delegates and guests.

At the final meeting of the delegates the following state officers were elected: Charles Dowd, president; James J. McGee, vice-president; Elmer E. Thomas, secretary-treasurer; Oscar A. Thomas, conductor; Andrew A. Anderson, doorkeeper; Bernard J. Reynolds, trustee. The officers were installed by National President James R. Coe, who also presented a past-president's jewel to the retiring state president, Thomas J. Phillips.

At a meeting of the Connecticut State Supplymen's Association, held on Saturday morning, these officers for the ensuing year were elected: Edward J. Birge, president; John H. Foote, vice-president; Harry H. Glynne, secretary-treasurer; George H. Kendrick, chairman; N. S. Burnham, John F. Harrington, William Muller and Frank T. Bulkley, trustees.

THE EXHIBITORS

Bridgeport No. 4, N. A. S. E.
Garlock Packing Co.
McLeod & Henry Co.
Eagle Oil & Supply Co.
Dearborn Chemical Co.
American Steam Gauge & Manufacturing Co.
Greene, Tweed & Co.
Philadelphia Grease Manufacturing Co.
Peerless Rubber Manufacturing Co.
Durabla Manufacturing Co.
McClave-Brooks Co.
Pratt & Cady Co., Inc.
Nightingale & Childs Co.
Hartford Mill Supply Co.
The Lyon & Grumman Co.
The Hawley Hardware Co.
Kilpatrick Hotz Co.
J. H. Richardson
Robert A. Keasby Co.
Perfection Grate Co.
Pyrene Sales Co.
Jenkins Bros.
Otis Elevator Co.
Keystone Lubricating Co.
The Lunkenheimer Co.
Diamond Power Specialty Co.
The C. S. Merrick Co.
H. W. Johns-Manville Co.
"National Engineer"
"Power"
The Wellington Co., Inc.
Wm. L. McLellan
Home Rubber Co.
Crane Valve Co.
The Babcock & Wilcox Co.
Crandall Packing Co.
The Roto Co.
Mason Regulator Co.
Walter G. Ruggles Co.

The next convention will be held at Hartford in June, 1915.

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Government Coal Analyses

Dealers and users are depending more and more on government analyses for comparison and for determining the best and cheapest fuel. Each summer the Geological Survey issues a small pamphlet giving analysis made by the Bureau of Mines of the coal samples that the Survey has collected during the year. These analyses are made for the purpose of obtaining data upon which to classify and value the public lands, and for general information regarding the various coal fields of the United States.

The latest pamphlet of this series (Bulletin 541-K) gives the analyses of 135 samples collected by uniform methods in Alabama, Colorado, Illinois, Kentucky, Montana, New Mexico, Oregon, Pennsylvania, Utah, Virginia, West Virginia and Wyoming. The heating value is given with almost all the analyses, so that it is easy to determine which of two coals is the better. The bulletin also gives a brief description of the samples, including a section of the coal at the point sampled, and an outline of the different classes of coals recognized by the Geological Survey.

A copy may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

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Progress of Department of Machinery, Panama-Pacific Exposition

Since the return of Lieut. George W. Danforth, U. S. N. (retired), chief of the department of machinery of the Panama-Pacific International Exposition, from a tour of the Eastern States, the department has been engaged upon the allotment of space in the Palace of Machinery. As so many applicants asked for a large space, the 360,600 square feet were over-applied for and it became necessary to reconsider each application so that all allotments have been appreciably reduced.

The exhibits will comprise the finest collection of electrical and machinery exhibits ever assembled under one roof. The exhibitors are coöperating with the department in associating their exhibits with others which will permit of complete operation and demonstration.

On April 1, preliminary work was started on the installation of the first exhibit, a 500-hp marine Diesel engine, by the Busch-Sulzer Bros. Diesel Engine Co., St. Louis, and the first pile for the foundation was driven with appropriate ceremonies on May 27 by Captain Asher Carter Baker, director of the division of exhibits. The installation will cost $70,000.

The entrance to the Palace of Machinery will be handsomely decorated with palms and shrubs. To attract the non-technical visitor there have been arranged many spectacular exhibits through the operation of pumps, etc., and beautiful and artistic effects, such as water-falls and illuminated fountains.

The most modern methods of illumination will be displayed in connection with the exhibits and will interest the layman as well as the student and those vitally interested in such affairs. One phase will be the isolated electric-house-lighting systems for farm use compared with the most complicated systems for city lighting. The testing of the high-potential insulators and transformers will be made possible by arrangement with the largest manufacturers of high-voltage testing apparatus.

A feature of the Palace of Machinery will be the methods employed for the convenience of the visitors. A number of plans are now being tested to insure engineers and students the opportunity to make a careful examination of each exhibit in privacy and comfort. Reception spaces will be provided in connection with each exhibit and equipped with suitable fixtures which will enable technical visitors to prepare notes on the various features.

All of the working exhibits will be equipped with the latest "safety-first" devices and these guards will form one of the most interesting exhibits to the engineer and manufacturer.

The Department of Machinery will soon take possession of the offices which have been built inside of the Palace and will remain there until the close of the exposition. The gates will open Feb. 20, and will close on Dec. 4, 1915. Nine of the eleven principal exhibit buildings are now complete and the others will be finished in less than thirty days.

BOOKS RECEIVED

OIL FUEL FOR STEAM BOILERS. By R. T. Strohm. McGraw-Hill Book Co., New York. Cloth; 145 pages, 4½x7 in.; 63 illustrations; tables. Price $1.

COX'S COMMERCIAL CALCULATOR. By Edward L. Cox. Funk & Wagnalls Co., New York. Cloth; 101 pages, 7x11 in.; 99 pages of tables. Price, $10.

NEW PUBLICATIONS

FUEL. By J. S. S. Brame. Published by Longmans, Green & Co., London, 1914. Size 9x6 in.; 372 pages; 52 tables, 72 illustrations. Price $3.50.

The author's object is to place in the hands of technical men, not fuel specialists, as full information on fuels of importance as is possible in a single volume. In the preface he makes a plea for government laboratories for investigating the fuel (presumably of the British Isles) as the subject is studied by the United States Bureau of Mines.

The book is divided into four parts, treating of solid fuels, liquid fuel, gaseous fuel and the analysis, purchase and utilization of fuels. The author has collected a wealth of information from sources generally recognized as the best; in fact, this is one of the most complete treatises on commercial fuels that we have had the pleasure of reviewing.

MARINE STEAM. Second edition, 1914. Published by the Babcock & Wilcox Co., New York and London. Size, 7x10 inches; 220 pages; illustrated.

The second edition of "Marine Steam," just issued by the Babcock & Wilcox Boiler Co., is to the marine trade what "Steam" (by the same company) is to the stationary. This book contains a fund of general information besides the illustrated history of the evolution and the development of the water-tube boiler from its earliest forms. The marine types of water-tube boilers are dealt with in detail, showing all forms of Babcock & Wilcox marine boilers.

It is of interest to know that water-tube boilers are now in use aboard every type of steam craft, and in all the navigable waters of the globe. Many complete test reports are given in detail which afford a basis of comparison with others, ashore or afloat. The typography and the illustrations are excellent, which, coupled with the accepted reliability of the data it contains, makes this a reference book worthy of a place in any engineering library.

McANDREW'S FLOATING SCHOOL. By Captain C. A. McAllister. Published by International Marine Engineering, New York, 1914. Size, 9x6 in.; 245 pages; cloth. Price, $2.

Composed of reprints from "International Marine Engineering," the book is in the nature of story lectures on marine engineering to firemen, oilers, and coal passers, although engineers will find the book of value. A good conception of its purpose and treatment is gained by the following, which is in substance a synopsis of the first chapter. Four ambitious firemen aboard a coasting steamer determine, on arriving at an East River pier, to request the chief engineer, a man who worked himself up from the coal bunkers, to instruct them while the ship is idle during the winter when new boilers are to be installed. The chief agrees and the floating school goes into session. Beginning with simple explanations of force, work and power, the chief takes his class on through heat and the generation of steam, engineering materials, boiler fittings, draft, engines, condensers, pumps and all that marine engineers have to care for and manage. As the purpose of the firemen in taking instructions is to pass examinations and obtain engineers' licenses, questions and answers are given in the back of the book. There are thirty-eight illustrations and several tables.

STEAM SUPERHEATERS. By the Babcock & Wilcox Co., New York City. Cloth; 80 pages, 7½x10¼ in.; illustrated.

The Babcock & Wilcox Co., among the first, if not the first, to recognize the advantage of real technical and engineering worth in its advertising literature, has just issued a volume upon superheated steam, uniform in size, style and binding with its well known "Steam." It contains 80 pages, including many illustrations, and, in addition to describing the superheater as made by the Babcock & Wilcox Co. has a most valuable compilation of information upon the general subject. It would be fairer to say that it contains the descriptive matter in addition to tne compilation, for the latter is really the bulk of the book. After explaining the difference between superheated and saturated steam, the history of superheated steam from the time of Richard Trevethick is traced, an exhaustive chapter with charts and tables is devoted to the properties of superheated steam, while a chapter on the Advantage of the Use of Superheated Steam, with a discussion of causes and reasons, and illustrated by tests, leads naturally to the description of the superheater as made by the Babcock & Wilcox Co. The book is a fitting complement to "Steam," and will find as welcome a place upon the book shelves of engineers.

CHAIN GRATE STOKER. By the Babcock & Wilcox Co., 85 Liberty St., New York City. Cloth; 63 pages, 7½x10¼ in.; illustrated.

This book describes the automatic stokers of the chain-grate type manufactured by the company, with illustrations showing their application to various types of B. & W. boilers. The first chapter deals with the tendency toward increased overload, high efficiency and smokeless combustion, and points out that these results are better obtained by stoker-fired furnaces than by hand firing.

The advantages of the chain-grate stoker are enumerated, and the claim is made that it more fully meets the requirements of automatic firing than other types. Considerable space is devoted to the construction of the B. & W. chain-grate stoker, as well as to its application to various types of furnaces.

An interesting chapter deals with the furnace-fire brickwork, the quality of the bricks and what their condition should be when used in building the furnace linings and firebrick arches.

The volume is handsomely illustrated, showing installations of these chain-grate stokers to boilers with different types of furnaces, and contains tables showing the tests of boilers equipped with this stoker.

STEAM PIPES, THEIR CONSTRUCTION AND ARRANGEMENT. Published by the Vulcan Boiler & General Insurance Co., Manchester, England. Size, 8¼x5¼ in.; 108 pages. Flexible cloth. Price, 1 shilling.

This book, one of the engineering manuals put out by the above company, is chiefly for the purpose of promoting safety by practical literature on boiler subjects. Chapter one deals with steam velocity and draining of pipes. The book gives 60 ft. per second as the allowable velocity in steam pipes under 200-lb. pressure, with slightly higher velocity for lower pressures. The minimum diameter of steam pipe for an engine of good design may be obtained by multiplying the piston speed in feet per minute by the diameter in inches of the high-pressure cylinder and dividing by 1500, then taking the next larger size pipe. The velocity of steam in exhaust pipes with good vacuum may be allowed to reach 350 ft. per second.

The company does not recommend that steam pipes be laid to drain back into the boiler, but that provision should be made for draining a line at all points where water may collect. Consideration is given water separators, traps, material and construction of steam pipes, pipe and expansion joints, pipe standards, hangers and supports, exhaust-steam piping arrangement and fittings, and valves. Emergency-pipe work and insulating material are also included.

The book is excellently indexed and illustrated, and engineers and steam fitters should welcome it as a book that is truly useful.

Recent Court Decisions

Digested by A. L. H. STREET

Responsibility for Defective Engine—An employer is not liable for injury to an employee caused by automatically starting a stationary engine, due to a leaky throttle-valve, unless the employer was chargeable with negligence in permitting the engine to become or remain in a defective condition; the mere fact that such condition existed does not establish actionable negligence. (Alabama Supreme Court, Epsey vs. Cahaba Coal Co., 64 "Southern Reporter," 753.)

Risk Assumed by Electrician—An experienced electrician assumes the risk of being injured or killed through handling charged power wires with his hands, in removing them from one pole to another, if the accident be attributable to his failure to use the rubber gloves furnished him. In such circumstances, the failure of the company to shut off the current while the wires are being moved cannot be regarded as the direct cause of the accident. (North Carolina Supreme Court, Register vs. Tidewater Power Co., 81 "Southeastern Reporter," 326.)

Liability for Flooding Lands—A 3-ft. dam constructed in a creek to furnish water for generating steam in a power plant has just been held by the Indiana Appellate Court to have made the owner responsible to a proprietor of upstream lands in damages, for the consequent swelling of the waters of the creek, although the flooding was slight, the banks of the stream not being overflowed, and although the value of such lands was not depreciated. (Guynn vs. Wabash Water & Light Co., 104 "Northeastern Reporter," 849.) The court finds that nominal damages at least are recoverable. The decision is rested on the principle that the owner of riparian land is entitled to have the stream maintained in its natural condition, unless the right of flowage is acquired on payment of compensation to him.

Discrimination Between Public Service Corporations—A state law which prohibits a city council from granting permission to a public service corporation to lay pipes in a street or alley for the distribution of gas to consumers, unless the consent of a certain percentage of abutting property owners is first obtained, while water companies are left free to lay their pipes without obtaining such consent, violates the provision of the Illinois constitution. It forbids the passage of local or special laws granting exclusive privileges, according to a decision of the Illinois Supreme Court, announced in the recent case of People vs. Kewanee Light & Power Co., 104 "Northeastern Reporter," 680. Hence, the court finds that, so far as a law enacted by the Illinois legislature in 1897 discriminates in this manner, it is void. The law also discriminates against the erection of electric-light poles and wires in streets by requiring consent of owners of more than one-half of the abutting lands, whereas no such consent is required for the construction of wires and poles for the transmission of electric power.

Tank-Ship Explosion

Two explosions aboard the oil-burning tank steamship "Chenango" as she lay at South Pier, Robin's drydock, off Dwight St., Brooklyn, on June 9, set the vessel afire.

The chief engineer was rescued from the flames by the police and taken to the Holy Family Hospital severely burned.

The "Chenango," which is owned by the Gulf Refining Co., was to leave the next day for Galveston. Allan P. Garrison, chief engineer, of Philadelphia, went down to the engine room to see that all was in readiness for the start. He carried a lighted lamp, and it was said the flames from the lamp ignited the gases from the oil fuel stored in the hold.

Both hatches were blown away and the report of the explosions shook the neighborhood. Police Lieutenant McMullin and a patrolman dragged the engineer ashore. An alarm brought the fire department and the flames were got under control after a two-hours' fight.

Westinghouse Strike Situation

The spirit of optimism seems to prevail among the officers of the various Westinghouse companies in the Pittsburgh district as to the strike situation, according to the last report from the officials, and there is a feeling prevalent that in a short time there will be a general movement to return to work on the part of a majority of their men.

A number of employees of the Union Switch & Signal Co. walked out at noon on a Friday without presenting any reasons for so doing. The company promptly announced that the works would be shut down until the following Monday, at which time the employees would be expected to return. Practically the full quota of men has now returned, and this, coupled with the unsuccessful attempt of the strikers to call out the men at the Westinghouse foundries at Trafford City, has given their cause a serious setback and seems to indicate a speedy return to normal conditions.

The management states that there has not been any change in its attitude with reference to importing "strike breakers," but so far it has devoted its energies toward safeguarding the valuable properties placed in its charge.

When asked as to the effect of the strike on the business of the companies, one of the officers stated that owing to the policy adopted several months ago of manufacturing goods for stock in order to provide work for its employees during the dull period, a large amount of goods, sufficient in many lines for several months' requirements, had been made and distributed to the company's warehouses in various parts of the country, from which orders have been filled daily without delay.

Hydro-Electric Plant at Long Lake Completed

With the completion of the new hydro-electric plant at Long Lake on the Spokane River, Washington, the Washington Water Power Co. will have four hydro-electric generating stations on that river.

The plant will have four generators of about 18,000 hp. each, with a continuous overload capacity of 25 per cent.; each generator will be connected to a 22,500-hp. waterwheel, the largest yet built. When completed, the Long Lake station will be the company's largest project. It is 30 miles from Spokane. Power is furnished by a dam 200 ft. high, creating a lake 23 miles long and giving a fall of 170 ft. This dam will give storage not only for the new plant, but also for the Little Falls plant, further down the river.

The Long Lake dam is unique in that it is the highest spillway dam yet erected for a hydro-electric development, and when the river is at flood more than 19 ft. of water will pour over its crest.

Conservation Matters Before Congress

President Wilson's declaration that Congress must pass a number of conservation bills before adjournment has aroused new interest in the question of water-power development and power sites. A general water-power bill and a revision of the laws relating to the building of dams in navigable streams have been favorably reported to the House, and are among the measures on which action is demanded by the President as necessary to a fulfillment of party platform pledges.

Announcement that an investigation of the Keokuk dam and water-power development will be made during the summer by a congressional committee promises to shed additional light upon the manner in which water powers have been monopolized under the old laws, as well as upon the methods by which the monopoly controls and maintains high prices to the consumer. The charge that the Keokuk dam obstructs navigation in the Mississippi will also be investigated.

Secretary Franklin K. Lane, of the Department of Agriculture, who is a single taxer, seems to have won the President and the entire Cabinet over to the belief in government ownership of hydro-electric power and power plants. Both the general dam and the water-power bills now before the House follow closely along the lines urged by him, which provide for limited franchises of fifty years to dam and power companies, and for the purchase of the property by the government at the end of the fifty-year term.

In the case of dams built upon navigable streams, it is proposed that the Secretary of War shall have the authority to regulate rates for power sold by dam companies when sold in interstate commerce. If the government takes over the property at the end of the franchise term, it is to pay the "fair value" of all the property owned by the company and all the capital expenditures it has been in connection with its business, and is also to assume whatever unfinished contracts the dam company may have entered into.

As a measure to prevent the further monopolization of power and dam sites without use, the pending legislation proposes that actual work upon the construction of dam and power works shall be begun within one year of the time the grant is made, and completed within three years.

The general provisions of the dam bill are made to apply to companies operating under existing grants or franchises, as well as to those who may hereafter be granted franchises. If these bills become law, the effect will be to place the government in the position of being able to take over all existing dam companies and water-power plants at the end of fifty years.

Large Gate Valves for New York Edison Co.

Perhaps the largest steel gate valves for superheated steam yet installed in any of the immense power plants are those recently built by the Nelson Valve Co., Philadelphia, for the New York Edison Co., New York City.

Seven of these valves were built and shipped in 50 days from the receipt of the order. Each open valve, from the top of the stem to the bottom of the body, stands 9 ft. 1 in. in height, and the two types weigh 3600 and 3900 lb. respectively. The hand-operated design is made with a large bushing just below the handwheel, which may be removed for attachment of spur gears if desired.

The other type of valve is fitted with spur gears, and bevel gears for chain operation. This valve will be placed in a vertical pipe line and the extension stem (to which is attached a bevel gear) runs through a wall for operating from another room. The valve can also be operated by chain, the chain wheel being attached to the valve stem. These valves will be used on header lines carrying 200 lb. pressure with 150 degrees superheat.

Each valve has a steel body and bonnet, with seat and disk wings of forged monel metal and a valve stem of rolled monel. Brackets are provided on the inside of the yoke to support the gland when repacking the stem; eye-bolts, at the top of the bonnet, swing out of the way so that the valve may be repacked. The steel and monel metals have a tensile strength of over 65,000 lb. per square inch, and their coefficients of expansion are practically the same.

ENGINEERING AFFAIRS

The Association of Edison Illuminating Companies Convention will be held at White Sulphur Springs, W. Va., Sept. 14 to 17, at the Greenbrier Hotel. The active work will be confined to about twelve general papers and ten special committee reports. A fine program of entertainment and sports has been prepared for the delegates.

National Association of Corporation Schools—The second annual convention of the National Association of Corporation Schools was held in Philadelphia from June 9 to 12, at the new auditorium of the Curtis Publishing Co. A number of men connected with the electrical industry were on the program, including Arthur Williams, New York Edison Co.; C. A. S. Howlett, General Electric Co.; F. C. Henderschott, New York Edison Co.; C. P. Steinmetz, General Electric Co.; M. W. Alexander, General Electric Co.; R. J. Watson, Westinghouse Electric & Manufacturing Co.; W. M. Skiff, National Lamp Works; S. W. Ashe, General Electric Co.; C. R. Dooley, Westinghouse Electric & Manufacturing Co.; J. C. Robinson, New York Edison Co.; William H. Tolman, American Museum of Safety, and Dr. C. A. Lauffer, Westinghouse Electric & Manufacturing Co.

PERSONALS

E. F. Goad has been appointed chief engineer for the Chicago Heights Pure Ice Co., Chicago, Ill. Mr. Goad was until recently with the Lake County Ice & Cold Storage Co.

J. Russell Hormell, formerly chief engineer at the Carnegie Coal Co. plant, at Charleroi, Penn., now occupies that position at the plant of the Lilley Coal & Coke Co., West Brownsville, Penn.

Walter M. Brainerd, formerly chief engineer and superintendent of the New York Masonic Temple, West Twenty-Third St., New York City, has been appointed secretary and treasurer of the Engineering Utilities Corporation, 1161 Broadway, New York City.

E. D. Rasmussen, formerly with the Allis-Chalmers Co., Milwaukee, Wis., as erecting engineer and master mechanic for the Oshkosh Grass Matting Co., Oshkosh, Wis., the past two years, was, on June 1, appointed superintendent of machinery of the Oshkosh Steam Boat Co. in addition to his present position.

William A. Bole has been chosen by the board of directors of the Westinghouse Machine Co. to be vice-president in charge of production and erection for the plants at East Pittsburgh and at Trafford. Mr. Bole has been in the continuous employ of the company since August, 1882, having successively filled the positions of general shop foreman, superintendent, manager of works and consulting engineer, and has therefore taken part in the growth and development of the company since it employed less than one hundred men until the present, when the total forces run up into the thousands of operatives.

OBITUARY

FRANK L. BUSEY

Frank L. Busey, a valued contributor to "Power," and engineer of the Buffalo Forge Co., died on June 7 at the Battle Creek Sanitarium. His death was due to spinal meningitis.

JACOB C SOTTER

Jacob C. Sotter, for fifty-seven years head of Sotter Bros. Boiler Works, Pottstown, Penn., an inventor and bank director, died on Saturday afternoon, June 20, after an operation ten days before for acute appendicitis. He left a fortune estimated at $1,000,000.

GEORGE W. NISTLE

The sudden death of George W. Nistle, one of the founders and vice-president of the Illinois Engineering Co., Chicago, Ill., is announced. He died on May 27, in his sixtieth year. His home was in Muskegon, Mich. Mr. Nistle was a member of the American Society of Mechanical Engineers, having joined in 1901.

CHARLES B. ELLIOTT

Charles Bradford Elliott, chief engineer of the Haverhill (Mass.) Electric Light Co., is dead at the age of 41 years. He was the son of the late Edwin G. Elliott, former superintendent of Bradford academy, who died two years ago, and Mrs. Mary B. Elliott, of Greanleaf Street, Bradford district. In addition to his mother, he also leaves a brother, George E. Elliott of 18 LeRoy Avenue, Bradford.

Mr. Elliott was one of the oldest employees of the electric company, having connection with it as chief engineer as early as the time it was located near the Boston & Maine depot under the old management.

He was a kindly, courteous gentleman, and highly regarded by the men at the plant. Mr. Elliott was a member of Merrimac Lodge, A. F. A. M., and of the Blue Room Club of Boston. He was unmarried.

CHARLES F. EIKER

Charles F. Eiker, treasurer of the Perolin Co. of America, Chicago and New York, died suddenly at Cleveland, Ohio, Saturday morning, June 6, where he had gone to fill a business engagement. When he left Chicago the evening before he was apparently in perfect health and contemplated his trip with unusual interest. It was to be a farewell greeting between himself and President Kopper, who had perfected all arrangements for sailing June 10 for a trip to Europe.

"It was indeed fitting that these two comrades," says an officer of the company, "who have labored with such unbroken harmony together in the development of Perolin products to their present standard, should have been together when the latch was lifted that welcomed one of them to eternity. Far be it from me to intrude a word of flattery on such an occasion; yet no man was more grounded in the principles of common honesty than Mr. Eiker, nor paid greater devotion to them in the practical affairs of life. No man possessed a kindlier nature, or could have been a truer friend or finer associate. There will be no change in the policies of our company and the business will continue without interruption."

POWER

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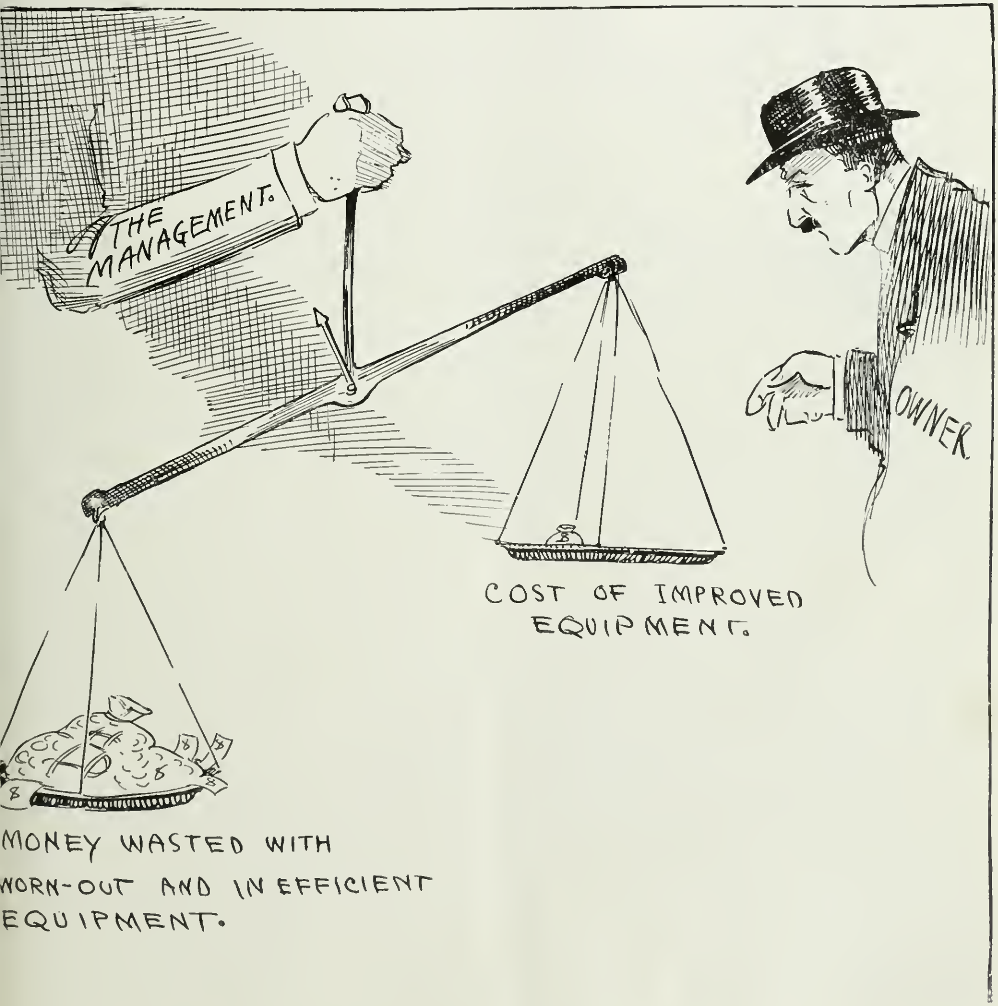
THE MANAGEMENT.
OWNER
COST OF IMPROVED EQUIPMENT.
MONEY WASTED WITH WORN-OUT AND INEFFICIENT EQUIPMENT.

HOW TO MAKE THE OWNER SEE IT

Repairs to a Large Chimney

By Charles H. Bromley

SYNOPSIS—The methods and material used to repair a brick chimney 350 ft. high and having a 28-ft. 6-in. base. Changes are made in the arrangement of the lightning conductors. From a stationary scaffold at the top of the chimney, painters' scaffolds will be hung, and all work done from them. Cotton rope is used. The repairs will cost about $10,000. The protective measures against liability for injury and death as adopted by the owners are explained. Twenty-four years ago a "jack" required two weeks to reach the top; this time the jack gets up in 15 hours.

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Preparing to Inspect the Chimney

A chimney 350 ft. high, 28 ft. 6 in. wide at the base and serving the boilers for the Clark Thread Co., manufacturer O N T spool cotton, East Newark, N. J., employing over 4000 hands, is an important part of the power plant. By means of a powerful glass, the upper part of the chimney may be closely viewed from the ground or roofs of the mills. Its condition is thus watched until the perceptible cracks, openings between the joints of the brickwork and the corrosion and disarrangement of the top plate and conductors warrant engaging a steeplejack to ascend the chimney and make a close-range inspection.

Reaches Top in Fifteen Hours

Twenty-four years ago this chimney was "pointed up" and repaired generally. The "jack" at that time required two weeks to build himself to the top (there is no permanent ladder), but John Cook, the man now doing the work, reached it in 15 hr. His methods, therefore, are interesting. Figs. 1 to 4 show the chimney, the steeplejack and a part of the brickwork pointed up some years ago with special cement.

To hold the ladders and pulley blocks, a "dog," Fig. 5, is driven into the brickwork, the rope hitches being so made as to be engaged by the projections. The dog has a chisel point. It may surprise many to know that most of the dogs holding the ladders are not driven in the chimney more than 2 in.

Mr. Cook uses ⅝-in. cotton rope of good quality wherever rope is required. Wooden ladders 12 ft. long, having 11 ft. effective length, after allowing for joining, are used for the straight run, while 24-ft. ladders were provided for getting out and over the "bell" of the chimney.

Method of Attaching Ladders

The method of putting up the ladders is interesting. Assume that the first and second ladders are in place at the base of the stack. Going to the top of the second ladder, the jack gets his legs around the ladder, as shown at the top of Fig. 1, and drives a dog into the chimney as high as he can reach. A 3-lb. machinist's hammer is used. A block-and-fall is attached to this dog and another ladder is hoisted by the helpers below. The sling is fastened below the center of gravity of the ladder so that the jack can tip it down to a vertical position preparatory to lowering it into the rung projection of the ladder below. The ladder is then tied to the newly driven dog and another is driven near the top of the topmost ladder, that ladder being then tied to the dog. This process is used throughout, with slight modifications where the 24-ft. ladders swing out over the bell.

Having reached the top, provision is made for fastening blocks-and-falls on which to hang two bos'n's chairs, one on each side of the chimney. These secured, the jack is pulled up by his assistants and the stack is inspected, each chair being pulled around to enable the workman to inspect the entire surface.

How the Contract Is Made

In the case of the Clark company the jack contracted to make an inspection and to report on the condition of the chimney. This constitutes a separate job. All the repair work will be done in this manner—i.e., the jack will receive a certain sum for pointing up the brickwork, another sum for repairing the lightning conductors, and so much for repairing the top plates, which have a total weight of six tons.

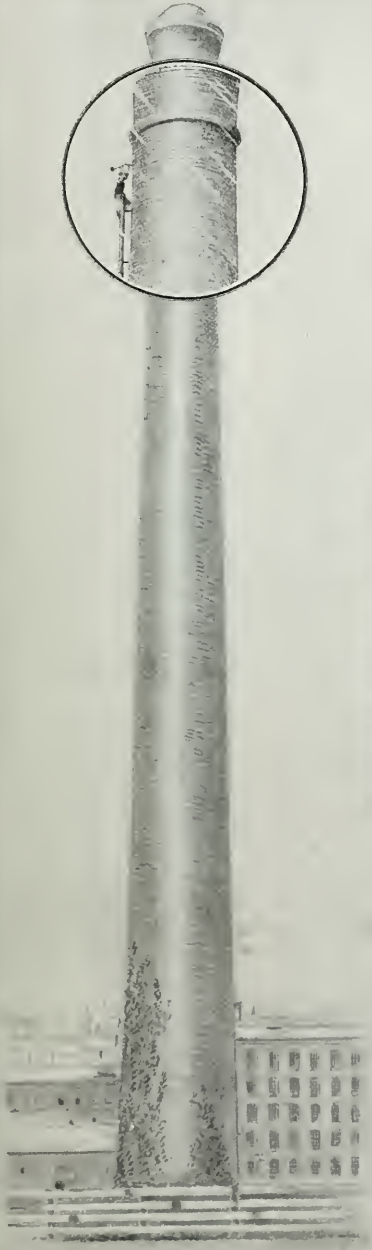
Protection against Liability for Accident

On account of the workman's compensation and employers' liability laws as they exist in many states, it is now general practice, where possible, to fence off a plot around the chimney, this inclosure being the jack's outright. "No Admittance" and "Danger" signs are conspicuous. If a company employee goes inside and is injured or killed, the company is not responsible; neither is it in anyway liable for injury or death to the jack or his men; the former is heavily insured, a special policy being carried. Figs. 1 and 4 show the inclosure; notice the jack in the chair in Fig. 4 ready to be hoisted. One gets a good conception of the size of the chimney base from this picture and, from Figs. 1 and 8 is able to appreciate its height.

A few years ago the chimney was struck by lightning, and this, perhaps, accounts for two cracks, one about 10 ft. long, near the top, and another approximately 40 ft. long, about 40 ft. below the top crack. At places along the large crack a strong odor of gas proves that the crack is through the brickwork. The cracks will be filled in, and the larger one, in addition to filling, will have two or three heavy gunmetal bands fitted to reinforce the chimney at that point.

Repairs to the Lightning Conductor

The present lightning conductor consists of a 2⅜x1¼-in. copper band bolted to the top of the iron plates on the bell. Connected to this band are four 1¼-in. copper "points," spaced equidistantly and rising vertically for 20 in. Another 2⅜x1¼-in. band is fastened below the bell, as in Fig. 6. To these two bands are bolted 5/32x3⅛-in. copper strips, the latter, on the north and south sides, running to the ground, where the coils shown are placed in a bed of gas retort carbon about 2¾ ft. below the surface. Spaced 11 ft. 4 in. apart are ½-in. round copper points which project 4 in. at right angles to the length of the chimney. The copper strips are looped to a 1½-in. radius, the loops being spaced 11 ft. 4 in. apart, a point



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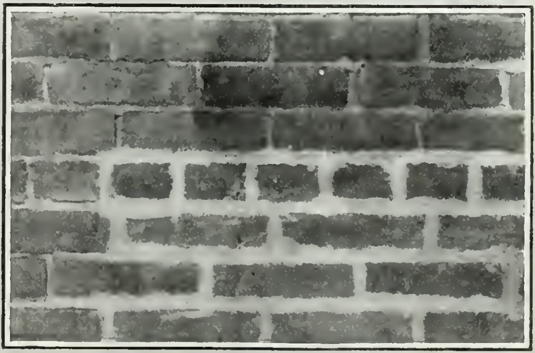

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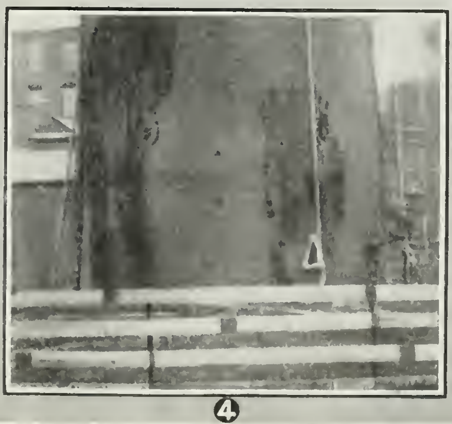

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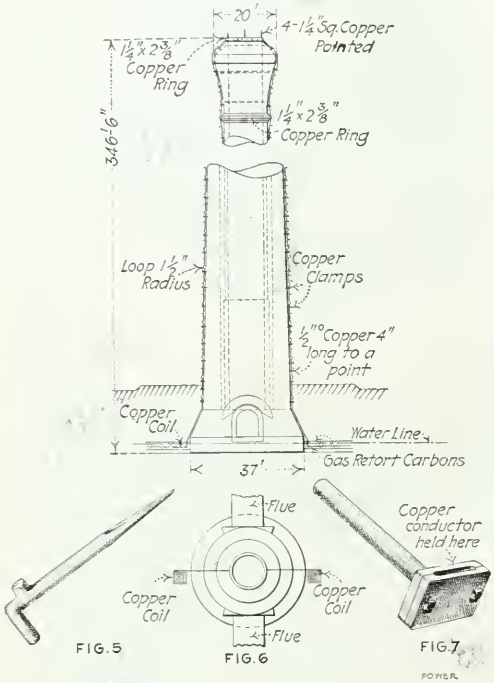
Views of the Chimney and the Steeplejack

Fig. 1. Putting up the ladders as seen through a telescope. Fig. 2. John Cook, steeplejack. Fig. 3. Wall pointed with high-grade cement. Fig. 4. At the base of the chimney.

being placed between each loop. The clamps used to hold the strips are merely pieces of 2⅜x¼-in. copper, long enough to cover the strip and leave room for nailing it to the brickwork. All these features are shown in Fig. 6.

Changes are to be made in the arrangement of the conductor. Instead of a ring at the very top, one will be placed about 6 ft. below, and another in the place now occupied by the present lower one. Points a little over 6 ft. long will be placed vertically on the top ring, and braced from the top plate. A more substantial clamp, such as shown in Fig. 7, will be used. To set the new clamps, the chimney will be drilled to admit the shank its entire length: broken brick will be driven in around it and thin grouting poured in.



DETAILS USED IN STACK REPAIR

Fig. 5. "Dog" used by the steeplejack. Fig. 6. Showing arrangement of lightning conductor. Fig. 7. Clamp for copper conductor strips.

From the ground to a height of about 80 ft., the conductor is as sound as when put on 24 years ago, but it is corroded away perceptibly above it. Viewed from the ground, the lower part is black, and then as the corroded part is reached it appears bright, having a whitish-green color where most corroded.

THE STATIONARY AND MOVABLE SCAFFOLDS

Preparatory to pointing the brickwork, a stationary scaffold is built at the top of the chimney immediately under the bell. It is simple, consisting mainly of 4x6-in. planking, 24 ft. long. There are four of these planks, joined and situated as in Fig. 8. After the brickwork above the floor is pointed, two painter's scaffolds will be

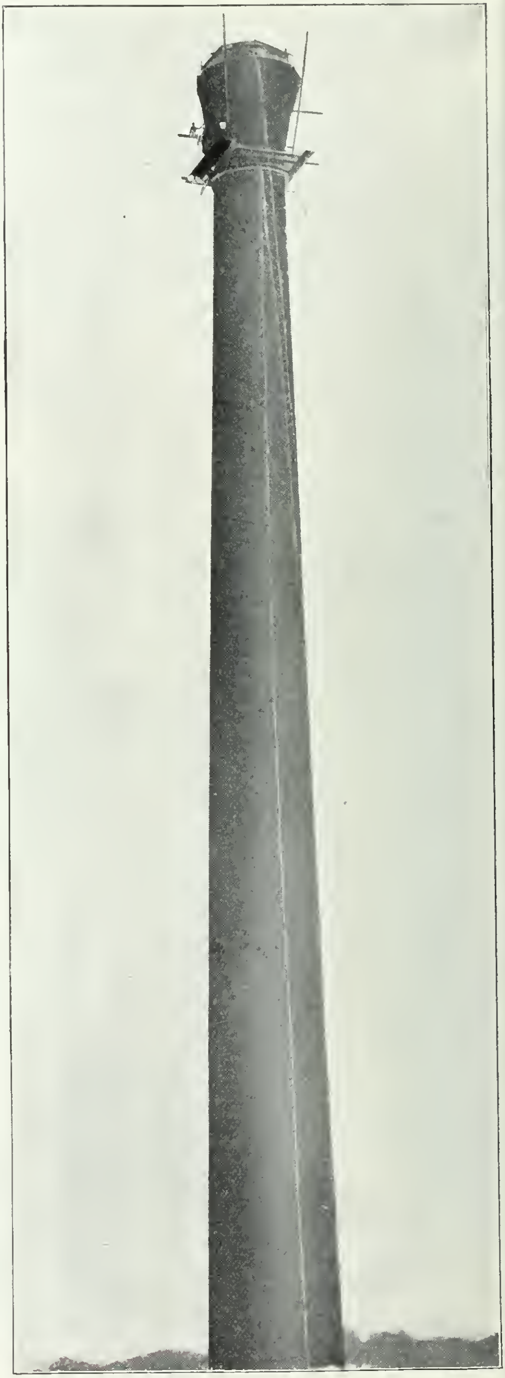


FIG. 8. SHOWING THE STATIONARY SCAFFOLD

hung from the stationary one, and from these all work below will be done.

The approximate cost of all repairs is $10,000.

Composition of Cement for Pointing

The cement used for pointing is most durable; Fig. 3 shows a wall partly pointed over three years ago. The cement is very hard, and when a knife is used to chip it off to test it, the brick will break off with the cement. The jack stated that this cement will outlast any other made. Although the old cement in this wall was put on years before the new, and should therefore show signs of deterioration, it will be noticed that there is a big difference in quality in favor of the new.

This cement is made as follows: 47 per cent. burned white sand (passed through very fine mesh screen), 46 per cent. whiting, 5 per cent. red lead and 2 per cent. litharge. It must be well mixed while dry, and turned four or five times. Enough boiled linseed oil is used to give it a not too thick consistency. A charge of $1.50 per square yard is made for pointing with this cement.

The repairs are being done by John Cook, South Orange Ave., Newark, N. J., who takes pride in relating that he has worked on most of the highest chimneys, spires and bridges in the world, and will continue until—well, until he drops. He will do this some day, for, he says, "They all do."

* *

Compressed Air in Mill Work

The variety of uses to which compressed air may be profitably put in a manufacturing plant is exemplified at the mills of the Burgess Sulphite Fibre Co., Berlin, N. H. The principal output is sulphite fiber pulp.

As the plant is built on rocky ground, each addition or extension to the building, and each alteration, such as changes in piping location, means removing rock or cutting holes in concrete walls or floors. For this work about 15 compressed-air, hand-hammer drills are necessary. Air is also employed in boring holes in wood and metal, about 20 small pneumatic boring tools being kept on hand for these jobs, and used also for rolling boiler tubes, etc.

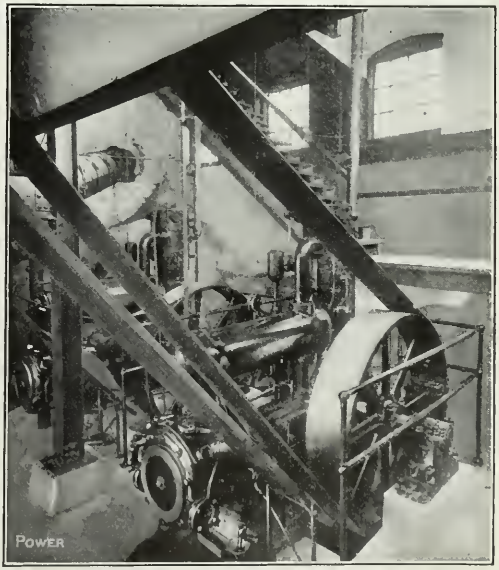
There are 18 digesters, each about 15 ft. in diameter and 50 ft. high. The shells are made of very heavy steel plates to withstand the steam pressure of 80 lb. To protect the plates from the action of the sulphuric-acid fumes, the interior is lined with a special firebrick, the joints being laid in a special acid-resisting cement. When defects are found in this lining, as happens occasionally, they must be repaired immediately so that no acids may penetrate through to the exterior steel plating. In making these repairs, pneumatic chipping hammers are used to cut out the brick.

The gate valves, 10 in. in diameter, at the bottom of the digesters were formerly opened by hand, a somewhat laborious process with 80 lb. pressure behind them. They are now opened by rotary air motors, connected to pulleys mounted on shafts, which in turn are geared to the valve stems. These motors are reversible, so that the valves may be opened or closed. There are air whistles at a number of points in the plant for signaling purposes, etc.

The finished pulp is conveyed from one point to another by wood-stave pipes made of narrow strips of wood of the desired diameter, and held in shape by ¾-in. hoops of round iron placed at frequent intervals. The hoops are formed at the plant by a set of bending rolls operated by a pneumatic rotary drilling tool. The hoops can be bent up in a few minutes to meet all the requirements for some time, and the rotary drill is then available for other use.

Air hoists are also placed at various points in the mill for raising the covers from the digester tanks or for similar work.

Another incidental use of air consists in rethreading the numerous odds and ends of bolts that accumulate about a plant of this sort, a rethreading machine, driven by a rotary air tool, having been arranged recently to recut or clean the bolt threads.



Motor-Driven Angle-Compound Air Compressor

Air Compressors

Compressed air for the various tools and operations is supplied by two Sullivan angle-compound compressors, with low-pressure cylinders 16 in. and high-pressure cylinders 9¾ in. in diameter; the stroke is 12 in.

These machines, shown in the illustration, are driven by a belt from individual 115-hp. motors mounted above them. Each compressor supplies 628 cu.ft. of free air at 225 r.p.m. Ordinarily, but one machine is operated, the second being held in reserve.

This new type of air compressor (described in the Dec. 9, 1913, issue of Power) was selected on account of its large displacement capacity as compared with the small floor area required. As the engine room had to be excavated out of the solid rock, it was important, for construction reasons alone, that the air plant should occupy as little room as possible. The overhead drive was another device adopted to economize floor space. These machines have been installed for nearly a year and have given satisfactory service.

* * *

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., has difficulty in identifying the return water in the pipe as merely a liquid piston in a long cylinder against which the steam acts. Chief Teller endeavors to make the matter clear.

*

"Chief Teller, I may be like the fellow who understood all about an automobile except how it could go without a horse hitched to it, but I don't quite see how the indirect coils in the sub-basement keep clear of water when some of them at the far end of the building are only a foot above the floor. The trap is on the floor, but the basement floor is 8 ft. below that of the power house, and the top of the open tank again is at least 6 ft. above the floor, making 14 ft. elevation in all. How does the water get back without a pump to push or pull?"

"The coils do keep clear of water when you keep 5 lb. steam pressure on the building, don't they, Will?"

"Yes, chief, and that's what I can't see through."

"Suppose we use a glass U-tube about half filled with water to demonstrate. If all pipes were made of transparent glass, we could then easily catch onto some things hard to understand in dealing with steam, air and water in heating systems. Here we are (Fig. 1). I keep this bent-glass tube for just this purpose, and by keeping in mind its lessons the whole matter becomes easier to reason out

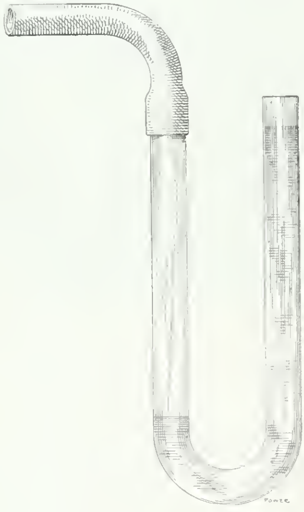


Fig. 1. A U-Tube

"Now, see how the water acts when you exert even a slight pressure of air on one leg of the tube. If you introduce more water into the air space it will overflow at the other side, but the difference in level will remain the same as long as the air pressure remains constant. The steam pressure acts in just the same way in the heating system. There would be no danger of the radiators flooding with pressure on. A pressure of steam on one side will force the water down in that side and up in the other. The difference in the levels will be a column of water, the weight of which is equal to the pressure exerted by the steam. If the water is cold, approximately 60 deg. F., the height for a 5-lb. pressure will be about 11.5 ft.

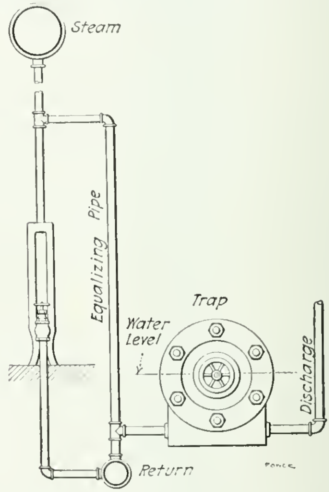


Fig. 2. Trap above the Return

"The rule is to multiply the pressure by 2.3 to get the equivalent in feet elevation, or, each foot in height is equal to 0.434 lb. (a little less than one-half pound) pressure. These two constants are mighty handy to remember, Will.

"As the water we are dealing with is hot, it is not so heavy per foot of elevation. Besides, the small amount of steam present incidental to the release of pressure helps to lighten the column and to increase its velocity, so that with a 5-lb. pressure, we have an active return and the radiators clear of water.

"You will notice that in this diagram (Fig. 2), the trap is about 18 in. above the return in the basement, which is on the same level as the power house. This is all right although it seems contrary to the rules.

"When this trap was first installed the steam fitter had not connected the equalizing pipe and the basement sounded like a boiler shop, the pipes hammered so. The reason was that the return lines had steam and water flowing through them at the same time. The slugs of water traveling at a rapid rate and coming in contact with one another and the short-turn fittings caused water-hammer. In other words, it was neither a wet nor a dry return. As you will see, the trap is connected on what is equivalent to the discharge side of the U-tube, so that all the water would be driven out of the system when the trap was in the discharging or open position, and when in the other or close position the lines would have to fill with water again before the trap would discharge. The whole operation would be noisy. The equalizing connection is made from the steam header, or its equivalent, to the inlet side of the trap, so that the water level is maintained at the level of the trap.

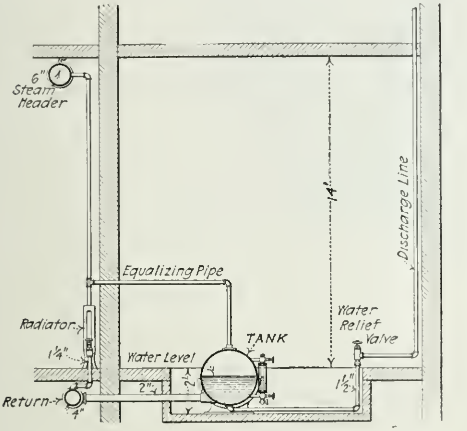


FIG. 3. A SPRING-LOADED VALVE AND NO TRAP

"Now, if you put an adjustable, spring-loaded valve (it is commonly called a water-relief valve) in the equalizing pipe line the level of the water can be regulated by it to any point below the trap level.

"Keeping the U-tube in mind, consider a trap as connected on its discharge side. With sufficient pressure, the water will be expelled downward and entirely out of the one side and up the other to the trap. But this is not a desirable condition for a heating system, because, as before stated, the water and the steam would mingle and cause water-hammer. The equalizing pipe is virtually a bypass connection between the two sides of the U-tube at some point above the bottom. It is obvious, then, that the bottom of the U-tube (or its equivalent, the return line) cannot be emptied by air or steam pressure, while the bypass remains open or unobstructed. The result is that by the use of resistance the water will be driven down until it reaches the desired level and not below it. The amount of resistance used will determine the relative level on the two sides.

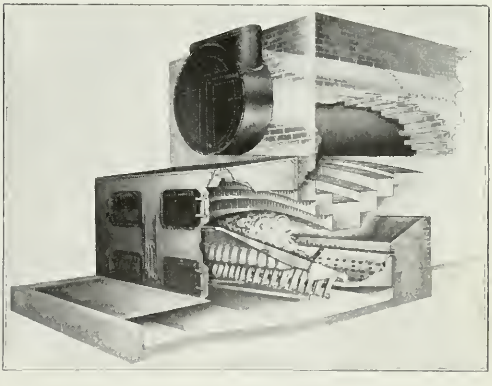
"Suppose, then, that it was not convenient to locate the trap just at the level it is desired to have the fixed water line, it can be located above that point by putting a spring-loaded valve in the equalizing or bypass pipe. In other words, for any desired difference in level the resistance of the valve must equal the amount of the unbalanced weight of the two columns of water.

I have used a spring-loaded valve alone, without a trap. Fig. 3 shows the conditions in that case. The steam pressure was constant and the discharge at the ceiling of the basement had a height of 14 ft. By simply adjusting the tension on the water-relief valve, the water level was established and maintained at any point desired in the down side (of the U-tube), as shown by the gage-glass. This level did not vary more than 1 in. in operation."

National Smokeless Stoker Grate

The furnace shown has been designed to burn, efficiently and without smoke, any kind of low-grade nut or slack coal. It is equipped with an inclined grate having two fuel pushers operated by the levers shown and an ash-dumping plate at the rear; it may also be operated from the front of the furnace. To secure smokeless combustion, a quantity of coal is stored directly inside of the firing-door, where the heat reflected from the arch drives off the volatile gases. Air entering through small holes in the firing-door combines with the gases, and the mixture is burned as it passes over the incandescent fuel at the rear of the grate, which receives its air supply from the ashpit.

Each shifter is made up of a series of sector-shaped elements attached to connecting links which are pivoted to a rod running crosswise with the furnace. Normally, the elements are flush with the grate, but by means of the operating levers they may be raised through spaces in the grate to push the coal toward the rear. The arc at the larger end makes it possible for the sectors, in any position, to fill the openings and prevent fine coal falling through to the ashpit. The dump plate is pivoted back of the center to give a large opening for clinkers, and the rear part of the plate is curved upward, so that when the ashes are dumped it will project over the opening and tend to push the clinker down to the ashpit.



SHOWING STOKER AND FURNACE

When the incandescent coal on the lower shifter has been nearly consumed, it is dumped onto the ash plate at the back, and the elements of the shaker are brought back to their normal position to receive the coked coal pushed back by the front shifter. The fresh coal then moves onto the front shifter, where the coking action is completed. It is possible to insert a large charge of coal at each firing so that the door is opened only at long intervals and conditions are right for smokeless and efficient burning and reduced labor by the fireman. By reason of the correctly designed combustion arch and the manner in which the coal is progressively fed down the grate, automatic stoker conditions and economies can be duplicated with this furnace at a cost slightly in excess of that of a stationary grate installation.

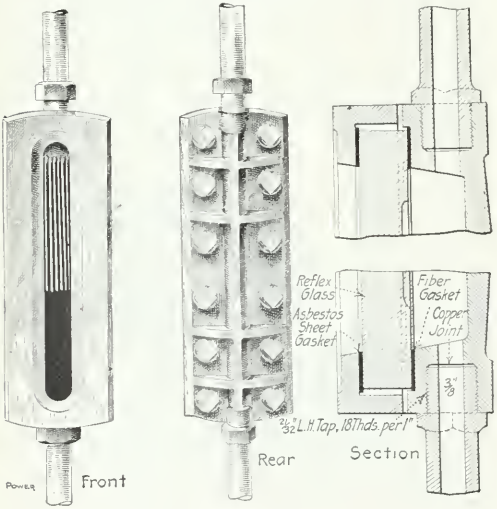
The furnace is designed and manufactured by the New Albany Manufacturing Co., New Albany, Ind.

⁂

Standard "Okadee" Reflex Water Gage

In line with the slogan "Safety First," the Engineers Specialties Co., 333 South Dearborn St., Chicago, is putting out a water gage with a flat glass about ¾ in. thick for stationary and marine work. The gage has been in use in the locomotive field for a number of years.

As indicated in the drawings, the glass is clamped between two naval bronze castings, with a passage for water and steam at the rear. On the water or rear side the glass is corrugated so that there is no reflection of light, and the water getting into the grooves appears jet black. Above the water line the glass has a white metallic appearance so that the contrast is decided, thus the water level may be seen easily from any point in front of the gage. The glass is thick enough to withstand any pressure used in boilers. There is no breakage and flying of glass as with the ordinary round tube. On rare occasions the glass has been known to become friable in spots and a small pinhole leak will develop. In such a defect there is no particular danger to the fireman, however, and the remedy is a new glass.



Front, Rear and Sectional View of Water Glass

Brown Electric Indicating Pyrometer

Severe losses can occur in boiler operation from an excessive temperature in the stack, and the loss of valuable heat units which should be utilized under the boiler. Considerable data on boiler operation can be procured from measurements of the temperature in the furnace. Tests will show whether an excessive percentage of the heat is passing up the chimney; give the relative results secured from each boiler; and show if the fireman cleans the fires at the proper time and the flues are kept clean.

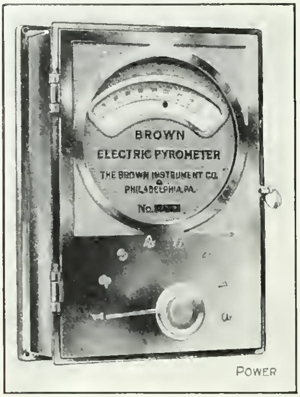


Fig. 1. Boiler Room Indicating Pyrometer

These temperatures can be readily noted by the use of the electric pyrometer, made by the Brown Instrument Co., Philadelphia, Penn., to indicate the temperature in either the first, second, third or fourth pass of a boiler; or at all these points if desired, and also, if convenient, at the top of the furnace.

One type of equipment is the indicating pyrometer, with a switchboard near the boilers, by means of which the fireman can switch onto the one indicating instrument. Thermocouples are placed in the various passes or in the firebox, and the temperature noted. At the same time the chief engineer should have a recording pyrometer in the office to keep a day-and-night temperature record on a chart, of either one or all of the boilers which are carrying a load.

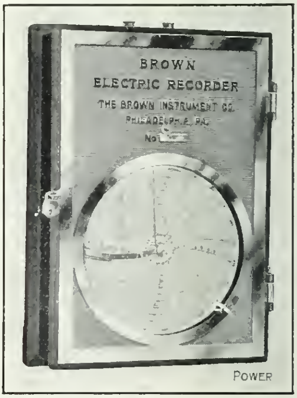


Fig. 2. Office Recording Instrument

Fig. 1 illustrates the standard form of the electric pyrometer, with a switchboard for the fireman to switch the instrument on to any boiler. Fig. 2 shows the recording pyrometer for the chief engineer's office.

⁂

Operators vs. Output—Contrary to what one might assume, a 20,000 or 25,000-kw. turbine generating unit does not require additional operators over a 12,000-kw. unit in proportion to the increase in output. The output, per man required for operating, increases from 40 to 50 per cent.

A Temporary Balancer Set

By C. V. Hull

The power system of a large manufacturing plant was changed from 110-volt generators on a three-wire circuit to 220-volt generators with balancer sets on the same circuit. Soon after the change, trouble with the commutators of the balancer set made several days' repair work necessary. It had been planned to have two balancer sets, but the second had not arrived and repairs had to be made and the power kept on. In order to prevent any shutdown, the electrical department arranged a temporary balancer set.

This work was handicapped because there were not two similar motors in stock, but two 110-volt motors were selected and fitted with pulleys of proper sizes to allow each to run at its rated speed. These motors were anchored in line and belted up.

The field current of each was carefully determined. Then the two fields were connected in series across the 220 lines. But to give the field requiring the greater current full strength, two small rheostats, *R* and R_1 were connected in parallel with the field of the motor which required the least current. This gave full field to both motors since the rheostats were adjusted to care for the difference between the two fields.

The armatures were connected in series across the 220-volt mains, and the current in starting passed through the rheostat *S*. After starting, the terminal posts were short-circuited by the single-pole, single-throw switch *C*, from which the current flowed through the armatures in series, then to the main through switch *D*.

The neutral wire was connected to the armature circuit by a big, old-fashioned single-pole switch *E*, which was used because it was the only one large enough in stock. Two small single-pole switches, *A* and A_1 were provided in the field circuit in case it seemed advisable to make any changes in the wiring or the rheostats mentioned. A permanent opening was also made in the field circuit in case repairs or changes were needed, since it was not certain that the outfit would do even temporary service.

No ammeters were installed as it was not thought necessary to know the amount of unbalanced load. Voltmeters were connected as usual and indicated practically the same voltage, showing the load to be fairly well balanced.

The starting directions for the men, who were engine operators and knew little of electrical work, were as follows:

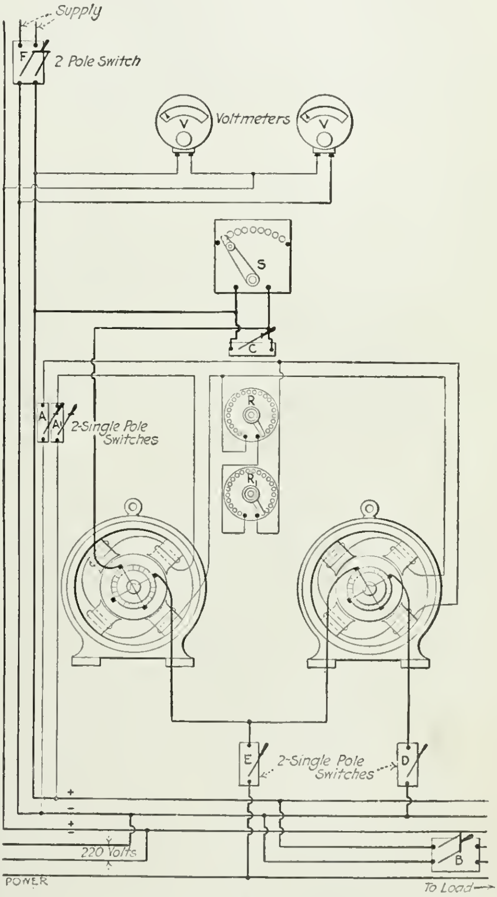
To start the balancer set:
- See that switches A and A_1 are closed.
- Close switch F.
- Move lever of rheostat S slowly to running position.
- Close main feeder switch B.
- Close switch C.
- Close switch E.
- Close switch D.

To stop the balancer set:
- See that main line switch B is open.
- Open switch F.
- Open switch D.
- Open switch C.
- Open switch E.

CAUTION—Be sure that the main line switch B is open until the balancer set is started and before stopping the balancer set. Do not pull any switch on the balancer board before B is pulled.

It will be seen from the directions that the balancer was started as two 110-volt motors in series on a 220-volt circuit. Then the neutral was cut in before the load switch was closed.

This temporary set did excellent service for some time. Of course, there were times when the voltage regulation was not all that could be desired, but the belt always stayed on even when the load was considerably unbalanced. The power service was always good, although the lights on the heavy side were sometimes dim for a few moments.

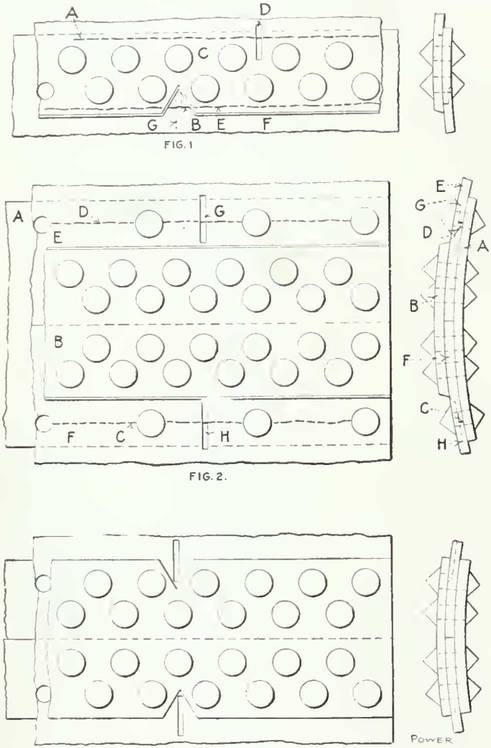


Wiring of Balancer Set

Despite the crudeness of the arrangement, the men had no real trouble with it. No one attempted to start the set without closing the field switches *A* and A_1. Once the main switch was closed before the set was started, which caused the breaking of a number of incandescent lamps. The outfit was so satisfactory that it was kept as an emergency outfit until a second set was installed for permanent use, as 24-hr. service made two sets necessary.

New Method of Detecting Cracks in Boiler Seams

S. F. Jeter, Hartford, Conn., has lately patented a means for detecting cracks at the seams of boiler shells before the cracks have become dangerous. The plan is to form one or more small pockets or slots in the plate or plates adjacent to the points where cracks are likely to occur. These slots are small enough not to appreciably decrease the strength of the plates. When the crack starts it continues until it opens into the slot in the plate, and then leakage of steam or water will occur to give warning of the presence of the crack before it extends completely through, or to the edge of the plate. Of course, the slots are not cut clear through the plate: they consist of a recess in the plate, making it thinner over the place where a crack may develop. The length of the slot must be run transversely of the riveted joint.



Where Slots Are Located for Different Kinds of Joints

In Fig. 1 is shown a lap joint with the places where cracks usually occur, *A* and *B*. Sometimes a crack *A* will start on the inner surface of plate *C* over the edge of the plate beneath and gradually work to the outer edge of plate *C*. Ordinarily, this crack cannot be seen until it has reached the outer edge of plate *C*, when a dangerous condition will have been reached. By slotting the plate *C*, as at *D*, and decreasing its thickness, the plate will crack through at this point and give warning that this seam needs attention. The same is true for a crack as at *E* in the plate *F*. A slot *G* is made on the inside of the plate *F*, and to promote observation of it a piece is cut out of plate *C* over the slot in *F*.

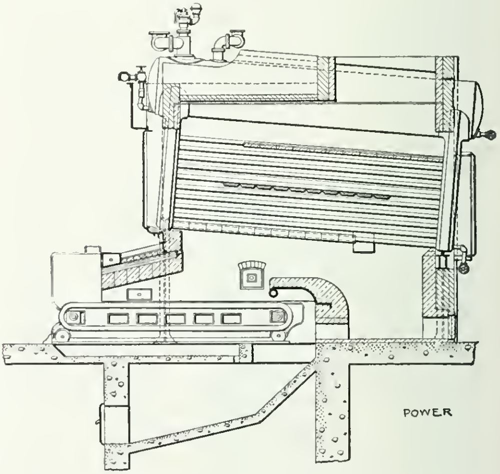
With a butt strap joint, Fig. 2, where the inside strap *A* is larger than the outside strap *B*, cracks *C* and *D* occasionally occur. Usually they cannot be detected until dangerous, because they are inside the edges of plate *A* and must come all the way through the plates before being detected from the outside of the shell. By slotting the plates *E* and *F*, as at *G* and *H*, steam will blow through, giving warning of the approach of a dangerous condition of the joint.

When the straps are the same width as in Fig. 3, sections of the outside strap may be cut away over the slots in the butting plates.

*

Boilers with Divided Baffling

The illustration shows a section through one of three Heine water-tube boilers, of 540 hp. each, at the Lytton Bldg., Chicago. They are equipped with McKenzie chain-grate stokers, with a divided-pass method of baffling, as shown. Each boiler is built for 200 lb. working pressure, with two large shells, of three sheets, $\frac{1}{2}$ in. in thickness. The longitudinal seams are of the triple-riveted, double-strap, butt-joint type, and the round-about seams with lapped joints, single riveted. The water legs are built of two sheets, machine flanged and joined by a butt strap along the bottom and sides; the legs are stayed with twice the customary number of hollow stay-bolts. Each boiler has three hundred and forty-nine $3\frac{1}{2}$-in. by 16-ft. seamless tubes, No. 9 gage.



Boiler with Divided-Pass Baffling

The boilers are supported on a steel chair at the rear, and cast-steel brackets, riveted to the sides of the front water legs, rest upon column supports.

The lowest row of tubes is encircled by L-tiles to within about 5 ft. of the rear water leg. This row of tiling serves as a roof for the furnace and combustion chamber and permits of a simple, standard arrangement of the stoker, with plenty of room to give the flames time to burn out without an excessively high setting. The flame travels horizontally and the gases burn out in the combustion chamber before reaching the tubes.

The middle baffle rests upon the ninth row of tubes, with an opening both front and rear. The top baffle extends from the rear to within several feet of the front water leg, leaving an opening for the discharge of the gases from the boiler tubes. The gases entering the boiler divide into two streams, one flowing beneath and the other above the middle baffle. The gases flow under the boiler drums before passing to the smoke outlet.

⁂

Hydraulic Water-Turbine Governor

An improved governor for water turbines wherein floating levers have been dispensed with, is illustrated herewith. The governor sleeve is mounted on an aluminum crosshead *C*, which rises and falls with the sleeve *S*, it is adjustable to take up wear, and is prevented from revolving by stops. One end of the crosshead is directly connected to the piston valve *J* and the other end to the plunger of the oil brake *W*; this gives a direct force couple.

The compensating mechanism consists of a bronze sleeve *E* which is a sliding fit in the valve body *A*, and inside of which the plunger *J* works. The sleeve is connected to the piston of the servomotor, as shown, or to some part of the gate-regulating mechanism; therefore, every movement of the piston valve is immediately duplicated by the sleeve.

An oil brake *W* is provided with a wide range of adjustment by means of the check valve *Y*. This controls the too rapid action of the governor, and prevents the valve sleeves or compensator from interfering with the action of the pendulum.

The body of the oil brake is coupled to the valve sleeves by the rocking beam *Z*, so that when the speed is changed and the valve sleeve moves upward, the compensating action causes the oil-brake body to move downward, and *vice versa*. The check valve *Y* on the oil brake can be so adjusted that, however sudden the change of load, the action of the governor pendulum is not interfered with by the back action of the sleeve. The rocking beam *Z*, the sleeve *E*, and the oil-brake body *W* are held rigid between every movement of the pendulum.

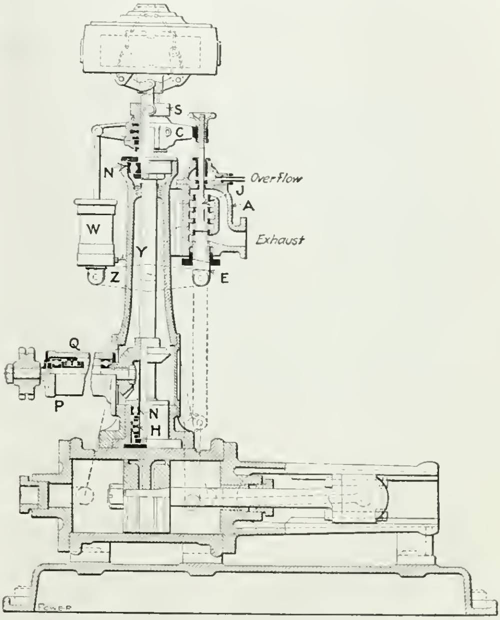
In the case of an impulse wheel with needle regulation or with a deflector, if it should be noticed that the governor carries a needle or deflector beyond the proper position and then oscillates several times after a change of load, it indicates that the oil brake is not slow enough in its action. The remedy is to close down the valve *Y* still further. If the governor does not open or close the nozzle properly, the valve on the oil brake is unscrewed a little more.

Another feature of the governor is that of throttling the exhaust instead of the supply to the valve *A*. This arrangement takes some of the strain off the piston valve, resists the wear, puts it in more perfect balance, and makes the relay piston easier to move.

The crosshead is fitted with double-ball thrust bearings to take the end thrust in either direction. The bottom of the main spindle also has a double ball-thrust bearing *H*, and the bearings at the top and bottom are ball-journal bearings, as at *N*.

The horizontal driving spindle is provided with two radial ball bearings *P* and a double thrust bearing *Q*, to prevent any tendency to end movement and take the thrust of the driving gear.

This governor was designed by Percy Pitman, 3 Willcott Road, Acton, London, W., England. Its claims are that it has a close speed regulation without hunting, that all parts are adjustable while it is in operation, and that it is automatic, hand or distant controlled. It is mounted on a self-contained bed.



SECTIONAL VIEW OF HYDRAULIC GOVERNOR

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Oil Engines in the United States—According to the report of the prime movers committee of the National Electric Light Association, there are at present 159 Diesel engine installations in this country. Thse are distributed geographically as follows:

State	No of Installations	Number Engines	Total Horse-power
Arizona	6	11	3,505
Arkansas	1	1	120
California	1	1	60
Connecticut	5	8	2,195
Florida	8	32	10,720
Illinois	6	11	1,530
Indiana	7	15	2,905
Iowa	1	1	120
Kansas	6	8	1,355
Louisiana	7	12	1,800
Maryland	1	1	225
Massachusetts	15	31	6,615
Minnesota	3	4	740
Missouri	3	8	1,815
New Hampshire	2	4	1,350
New Jersey	6	7	1,050
New Mexico	3	3	845
New York	10	21	3,130
Ohio	4	6	1,350
Oklahoma	4	4	845
Pennsylvania	6	20	4,135
Rhode Island	7	13	2,640
South Carolina	1	2	395
South Dakota	1	2	450
Tennessee	1	1	225
Texas	36	46	8,915
Wisconsin	5	13	2,265
Hawaiian Islands	1	1	225
Mexico	2	4	785
Total	159	291	62,310

Reducing Smoke with the Steam Jet*

By Osborn Monnett†

SYNOPSIS—Why a steam jet reduces the smoke and how to install it. Calculating smoke density.

⁂

Having taken up the problem of draft, which must be settled before a successful furnace can be installed, the design of the furnace will be considered. Many attempts have been made to design a simple, hand-fired furnace which would stand hard usage and reduce the smoke to a minimum, but few such furnaces would stand a close Ringlemann chart reading, such as is demanded by the modern smoke ordinance.

The first setting to come into general use in this country was the standard horizontal, return-tubular setting with plain grates, it being the simplest and cheapest setting that could be devised for making steam. It was extensively employed in the East, burning anthracite buckwheat coal with forced draft, and naturally came into common use in the West for bituminous coals before the smoke problem became important. Thousands of these standard settings are scattered over the country today, giving fairly good results for all around use. However, with Western bituminous coals the settings permitted excessive smoke. When smoke became a nuisance, in the eyes of the law, various attempts were made to overcome the difficulty and still retain the simplicity of the original setting.

Steam Jets

The steam jet was probably the first and most common device for reducing smoke. Fig. 1 shows a typical setting with one in use. The function of the steam jet is to produce a mechanical mixture between the gases and the air coming in through the grate and over the fire. Elaborations of the plain, hand-operated steam jet have been made in great numbers. Automatic valves for turning on and off and operating various tips, flaps, panels, dampers, etc., are used in various systems and strong claims are sometimes made as to their beneficial action. Many of these claims are based upon the supposed dissociation of steam into hydrogen and oxygen, and the consequent increased combustion due to introducing this free hydrogen with its high B.t.u. value to be again united with the oxygen present in the furnace.

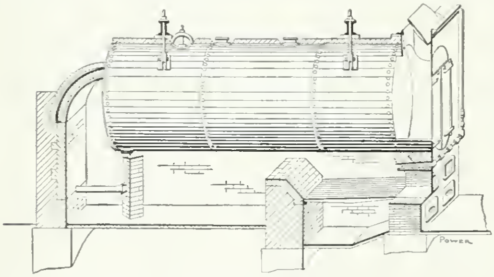

Fig. 1. Typical Setting with Steam Jet in Use

It must be remembered, however, that to separate a pound of steam into its elements, hydrogen and oxygen requires the same amount of heat that is given off when a pound of steam is formed by the union of hydrogen and oxygen, so that there is no thermal gain even if the steam is dissociated in the ordinary furnace, which is doubtful. If the action does take place there is bound to be a loss by radiation which could not be made up It is evident that the chief function of the steam jet is to mix the air and gases so that the latter may burn, if the temperature at the point of mixture is high enough.

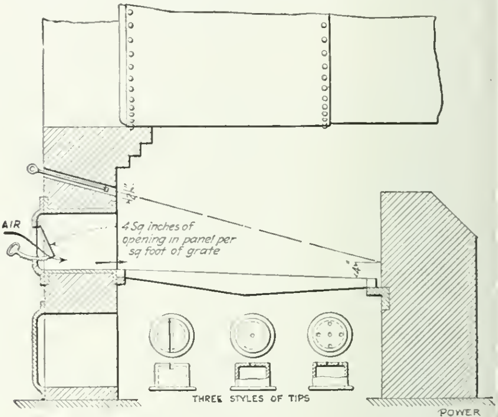

Fig. 2. Siphon Type of Steam Jet

The accompanying table represents a typical performance of an automatic steam-jet system on a plain horizontal, return-tubular setting carrying an ordinary working load. The table gives Ringelmann chart readings taken at 15-sec. intervals for a period of 1 hr. The blank spaces indicate no smoke. The results are reduced to the equivalent of No. 1 smoke and the mean density calculated as follows:

5 readings of No. 5 smoke = 25 units of No. 1 smoke
1 reading of No. 4 smoke = 4 units of No. 1 smoke
24 readings of No. 3 smoke = 72 units of No. 1 smoke
4 readings of No. 2 smoke = 8 units of No. 1 smoke
34 readings of No. 1 smoke = 34 units of No. 1 smoke
Total 143

The smoke unit is defined as 1 min. of No. 1 smoke, which is of 20 per cent. density. As the readings were taken every 15 sec., it follows that one-fourth the sum of the units in the foregoing table gives the smoke units for the observation. Thus

$$\frac{143}{4} = 35.75$$

The calculation for density is made by multiplying the smoke units by 20 per cent. and dividing by the number of minutes of observation, thus

$$\frac{35.75 \times 0.20}{60} = 11.9 \textit{ per cent.}$$

A plain setting and steam-jet equipment, either manually operated or automatic, will usually average from 8 to 12 per cent. smoke density. It has been satisfactorily demonstrated that a well designed, hand-fired furnace, handled properly, can be run within 5 per cent.

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*Copyright, 1914, Osborn Monnett.
†Smoke inspector, city of Chicago.

density and 2 per cent. has been obtained by careful operation. In reducing the density of smoke from a plain setting with steam jets, the trouble has been that immediately after firing an excess of volatile matter is distilled and carried off without being properly mixed with sufficient oxygen at a time when the temperature is high enough to produce complete combustion. It is evident that additional equipment is needed to insure a proper mixture. The combination of an automatic steam jet and brickwork suitably designed for furnaces such as will be described later, makes a good outfit for smoke suppression.

An ordinary hand-operated steam jet accomplishes a mixture of the air and gases, but its efficiency can be greatly increased by making it of the siphon type. This is done by placing the jet in an outer pipe 1½ or 2 in. in diameter, as shown in Fig. 2. The expanding steam fills the tubes and causes a suction of air into the furnace, where it is mixed with the volatile matter distilled after firing. The direction of the jet should be such as to strike the bridge-wall about 4 in. above the grates, as indicated in the drawing. Three forms of tip are shown at the bottom of the drawing.

RINGELMANN CHART READINGS

A. M. 10:00	0	15	30	45	A. M 10:00	0	15	30	45
1					31				
2				1	32				
3	3	3	3	3	33				
4	3	3	3	3	34				
5	3	2	1	1	35				
6	1	1			36				
7					37				
8	1	1	1		38				
9					39			5	5
10					40	3	3	1	
11					41	1	1		
12					42				
13					43				
14	3	3	2	2	44		1	1	1
15	2	1			45	1	1	1	
16					46				
17					47			1	3
18					48	3	5	5	3
19					49	1	1	1	
20					50				
21					51				
22		3	4	3	52				
23	1	3	3	3	53				
24	3	1	1		54				
25					55				5
26					56	5	3	1	1
27					57	1	1	1	1
28					58				
29					59		1	1	1
30									

Minutes observation, 60. Smoke units, 35.75. Per cent. density, 11.9.

❋

Quick Repair Job—An unusual boiler repair job was carried out recently when sixteen large cracks in the firebox of a large boiler were welded and the boiler was placed in service again within 48 hours' time, two men doing the job.

Improved Wing Turbine Blower

In Figs. 1 and 2 is shown the Wing Type E turbine blower, in which is incorporated a new feature in fan design. With ordinary straight casings, the air being thrown outward centrifugally strikes the casing, and although much of the air is delivered, considerable leaks back when it impinges against the casing. In addition to the air loss, there is a pressure loss due to the eddy currents caused by the impact.

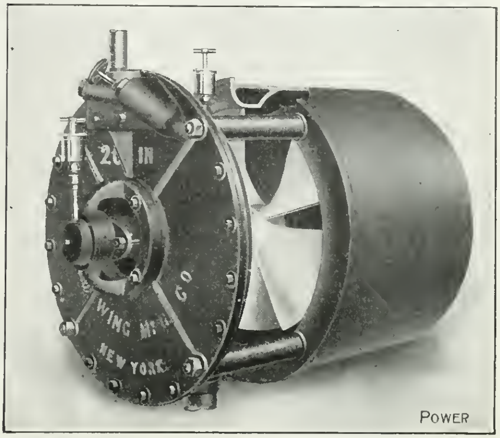


Fig. 1. Blower Casing with Portion Cut Away

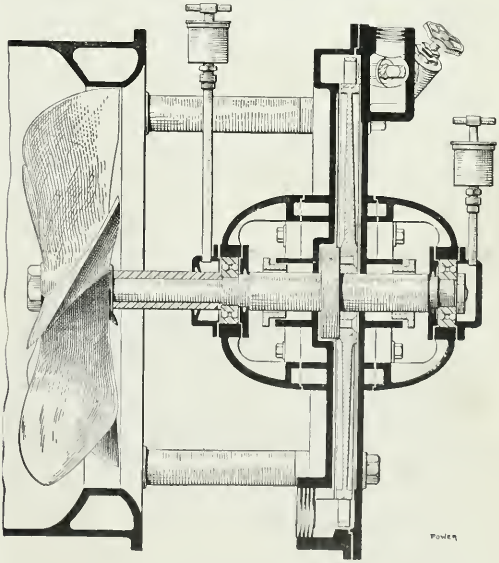


Fig. 2. Showing Details of Turbine Blower

In the casing of this blower, made by the L. J. Wing Manufacturing Co., 352-362 West Thirteenth St., New York City, the direction of the air is gradually changed from the radial or centrifugal—that is, out from the center—to axial, along the shaft. By the sweep of the patented expanding casing, an increase in fan efficiency of over 50 per cent. against the straight cylindrical casing is obtained. The five-bladed fan, of the propeller type used, is capable of delivering large volumes of air at pressures exceeding 4 in. water gage.

Fig. 2 is a sectional view through the unit, and shows the expanding casing, to which the turbine casing is secured by four bolts with sleeves. The fan and turbine are mounted on a steel shaft, with heavy ball bearings on either side of the turbine, so that there is no overhang to the machine. The machine will operate against either high back pressures or vacuum, and the exhaust steam may be turned into the ashpit if desired, or into the heating system or feed-water heater. The fan casing is secured in the masonry of the boiler wall, and whether the steam is turned into the ashpit or the heating system, or exhausts to the atmosphere, the machine is practically noiseless in operation.

⁂ ⁂

An Interesting Cylinder Failure

By H. B. Boydon

This failure occurred on a horizontal cross-compound Corliss engine 24 and 48 by 48 in. with an auxiliary high-pressure cylinder 20-in. diameter arranged tandem to the low-pressure cylinder, as shown in Fig. 1.

During summer the engine is operated condensing with a 1 to 4 cylinder ratio, the auxiliary high-pressure piston rod being disconnected from the tail rod of the low-pressure cylinder. During winter the engine operates noncondensing, exhausting against a varying back pressure into steam-heating mains. The auxiliary high-pressure cylinder is then in service, giving a resultant cylinder ratio of 1 to 2.36. Fig. 1 also shows the arrangement of the live-steam lines to the two high-pressure cylinders, the exhaust piping between these cylinders and the vertical receiver and from the receiver to the low-pressure cylinder. The engine was designed for an initial pressure of 140 lb.

In winter the engine is started from the throttle valve on the 24-in. cylinder, brought up to speed and the generator synchronized and put on the busbars. While being synchronized the throttle valve on the 20-in. cylinder is opened.

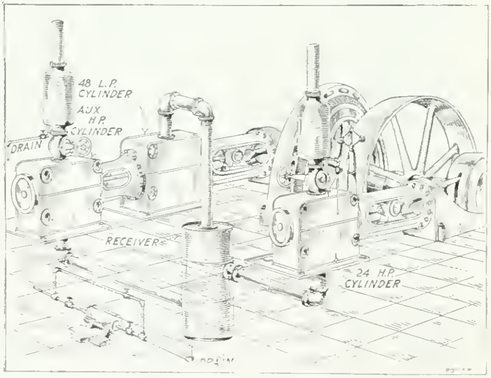


Fig. 1. Showing the Engine Piping

One winter morning just as the engine was up to speed, the steam chest of the 20-in. high-pressure cylinder cracked, as shown in Fig. 2. It will be noted that this crack extended the entire length of the steam chest except for the two outside ends of the valve chambers and entirely through the central webs of the steam chest.

A chart from a recording gage on the main steam header shows that when the accident occurred the steam pressure was about 162 or 163 lb. gage. On testing this gage it was found that 160 lb. on the gage was actually 155 lb., and that it was correct when reading 170 lb. It is, therefore, probable that at the time indicated the actual steam pressure at the point where this gage was connected was about 158 or 159 lb.

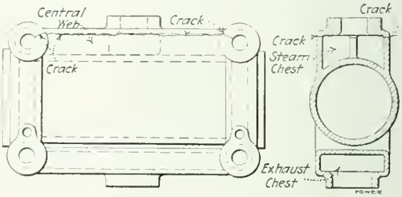


Fig. 2. How the Cylinder Cracked

From the main header the steam to this engine passes through two reducing valves, one on the steam pipe of each high-pressure cylinder. There is no evidence to show what the pressure was on the low-pressure side of the reducing valve. If it be assumed that the reducing valves were inoperative, the pressure at the engine-throttle valve at the time of the accident was probably about 158 lb. gage. This pressure would be insufficient to burst the cylinder.

The two engineers on watch at the time of the accident were questioned as to the facts in the case. It was stated by both men that it was customary before starting up an engine to open the drains and feel the discharge pipes to know whether or not they were in operation, but if this was the custom, it was done in a slipshod manner, and definite information was not gained as to whether the drains were open or closed, for examination of the drain pipe from the receiver separator on the steam line to the auxiliary cylinder showed that it was completely blocked up with a stiff pasty deposit. There was some difference of statement as regards the actua condition, at the time of the accident, of the throttle o the cylinder which broke. One man said it was closed the other stating that immediately after the accident h closed it, it being open about an eighth turn. By testing the valve it was found that this opening was not sufficient to move the valve off its seat, and it is entirely probable that the valve was actually shut when the accident occurred. Both men agreed that the engine was up to speed and was being made ready to be synchronized and connected to the busbars for carrying the load. Both also stated that there was no sound to indicate trouble. It is very doubtful if any sound could have been heard as the clatter of the valves of an engine running at full speed at no load is quite considerable. This would especially be the case as the clatter of the valves on the low-pressure cylinder would occur practically at the same time as noise in the auxiliary cylinder.

Referring to Fig. 1, it will be noted that the exhaust from the 24-in. cylinder enters the vertical receiver at a point above the exhaust from the 20-in. cylinder, also that the receiver is drained from the lower end through a trap which is fitted with a bypass. By trial it was found that the valve on the bypass of the trap was closed, that the inlet valve to the trap was open, but that the discharge valve from the trap was closed. No other drain being provided on the receiver, there was no means of getting rid of any accumulation of water in the lower portion of it. There is no exact information as to the steam pressure in the receiver at the time of the accident. It is probable, however, that it was somewhere between 2 and 6 lb. gage. The evidence, therefore, showed that the cylinder wrecked had a receiver pressure not exceeding 5 or 6 lb. and had a closed throttle valve.

The conclusion reached after examination of the evidence and the condition of the engine and piping was that the rupture was caused by water entering the cylinder from the receiver; that the piston in this cylinder operating without steam pressure on it, acted as a pump piston pumping water into the cylinder through the exhaust piping and exhaust valves, being assisted in this action by the pressure of the steam in the receiver, which in itself was probably sufficient to flood the cylinder with water. The exhaust chest was protected by the exhaust valves from rupture, and the steam chest being the weakest part, let go.

It is probable that the great majority of engines wrecked when starting up are not damaged by water coming in with the steam, but by water which is drawn into the cylinder through the exhaust valves from a flooded exhaust pipe caused by inadequate drainage of the exhaust piping.

⁂

Distribution of Heat in Turbine Plants

By H. Fothergill

SYNOPSIS—Simple diagrams representative of the distribution of heat in the several types of steam-turbine plant, which should help in the choice of a plant for a particular purpose.

⁂

Many diagrams showing the distribution of the heat obtained from a given quantity of coal have been illustrated from time to time, but the diagrams shown in Figs. 1 to 5 are perhaps the most simple and explicit yet devised for the purpose of illustrating graphically in connection with steam-turbine plants the percentage of heat units utilized and the percentage lost, of a given number of units which represent the thermal value of the coal.

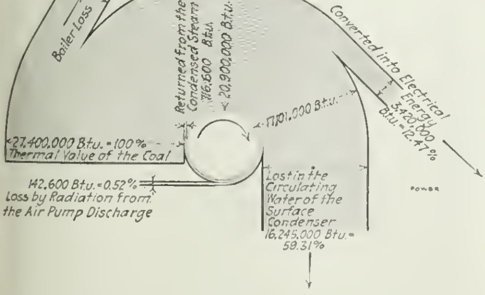

6,850,000 Btu.=25%
Boiler Loss
Loss in Pipes
363,400 Btu.=1.31%
Heat Losses in the Machine
379,000 Btu.=1.39%
Returned from the Condensed Steam 316,600 Btu.
20,900,000 Btu.
17,101,000 Btu.
Converted into Electrical Energy 3,420,000 Btu.=12.47%
27,400,000 Btu.=100%
Thermal Value of the Coal
142,600 Btu.=0.52%
Loss by Radiation from the Air Pump Discharge
Lost in the Circulating Water of the Surface Condenser
16,245,000 Btu.=59.31%
POWER

Fig. 1. Heat-Distribution Diagram of 1000-Kw. High-Pressure Condensing Engine

The calculations on which the diagrams are based were taken from actual results obtained by the Allgemeine Elektrizitäts Gesellschaft from their turbines. In addition to the usual high-pressure condensing turbines which have now become so popular in replacing the reciprocating engine in most modern electric-power plants, the A. E. G. manufacture back-pressure turbines, reducing turbines, low-pressure turbines and mixed-pressure turbines.

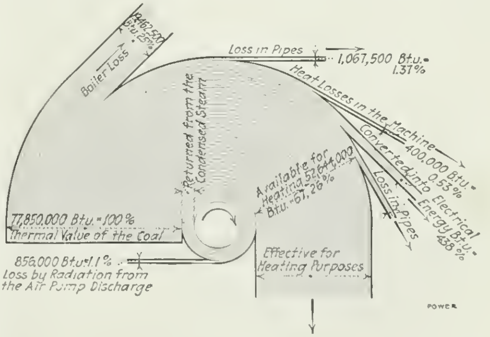

19,462,500 Btu.=25%
Boiler Loss
Loss in Pipes
1,067,500 Btu.=1.37%
Heat Losses in the Machine
400,000 Btu.=0.53%
Converted into Electrical Energy Btu.=4.38%
Loss in Pipes
Returned from the Condensed Steam
Available for Heating 52,644,000 Btu.=67.26%
77,850,000 Btu.=100%
Thermal Value of the Coal
856,000 Btu.=1.1%
Loss by Radiation from the Air Pump Discharge
Effective for Heating Purposes
POWER

Fig. 2. Diagram from 1000-Kw. Back-Pressure Turbine

It is not proposed in this article to enter into theoretical calculations or to consider the advantages and disadvantages of the various types of turbine referred to. The object is to lay before the engineer a simple diagram representative of the distribution of heat in each type of plant, so that he will be able to see at a glance which particular installation he should adopt and the percentage of heat units which he will be able to utilize beneficially.

HIGH-PRESSURE CONDENSING TURBINES

A diagram showing the heat distribution in a high-pressure condensing turbo-generator plant is illustrated in Fig. 1. To those who are not familiar with thermal-balance diagrams, the enormous quantity of heat which is carried away by the condensing water and lost, will no doubt seem surprising. With the object of avoiding this wastage, various combinations have been suggested. There are many plants which now use steam for heating as well as for power purposes, most common are those installed in large private undertakings, offices, hotels, chemical and celluloid works, paper mills, etc., and in such cases the usual practice is to install either a low-pressure boiler, specially for heating purposes, or to take live steam from the main boilers through a reducing valve. In this direction greater economy can be obtained by increasing the pressure of exhaust steam from a turbine and using this steam for heating purposes. Although this arrangement necessitates a back pressure on the turbine, the system will utilize a greater percentage of heat than a simple high-pressure condensing turbine.

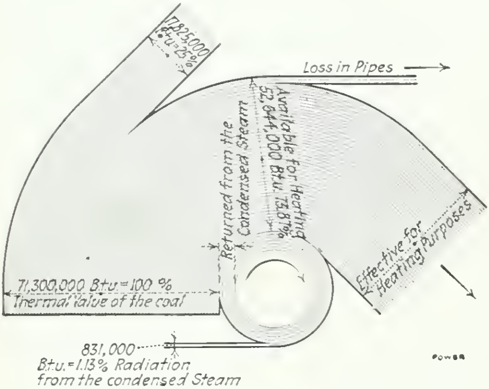

17,825,000 Btu=25%
Loss in Pipes
Returned from the Condensed Steam
Available for Heating 52,644,000 Btu. 73.87%
Effective for Heating Purposes
71,300,000 B.t.u.=100 %
Thermal Value of the coal
831,000 B.t.u.=1.13% Radiation from the condensed Steam
POWER

FIG. 3. HEAT DISTRIBUTION FROM LOW-PRESSURE BOILER

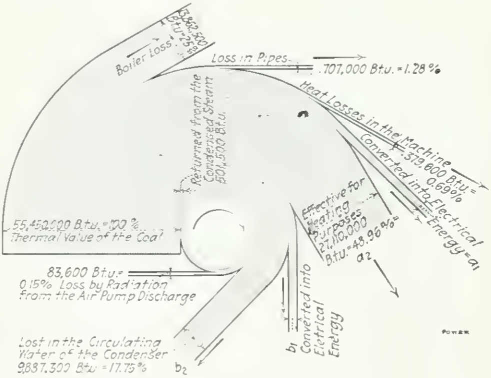

13,862,500 Btu=25%
Boiler Loss
Loss in Pipes
707,000 B.t.u.=1.28%
Returned from the Condensed Steam 501,500 B.t.u.
Heat Losses in the Machine 379,600 Btu.=0.69%
Converted into Electrical Energy=a1
Effective for Heating Purposes 27,110,000 B.t.u.=48.96%
a2
55,450,000 B.t.u.=100 %
Thermal Value of the Coal
83,600 B.t.u.=0.15% Loss by Radiation from the Air Pump Discharge
b1
Converted into Eletrical Energy
Lost in the Circulating Water of the Condenser 9,837,300 Btu=17.75%
b2
POWER

FIG. 4. DIAGRAM FROM 1000-KW. REDUCING TURBO-GENERATOR GIVING EXHAUST STEAM FOR HEATING PURPOSES

BACK-PRESSURE TURBINES

Fig. 2 is a diagram showing the heat distribution for a back-pressure exhaust turbine. The steam consumption of a 1000-kw. back-pressure A. E. G. turbine is 47.5 lb. per kw.-hr., with an exhaust pressure (back pressure) of 28.5 lb. per sq.in. Over two-thirds of the total heat value of the full amount becomes available for heating purposes. This figure will naturally be subject to slight variations depending on the relative position of the turbine and the apparatus to be heated, the lagging of the exhaust-pipe line, etc.

Fig. 3 demonstrates the heat distribution of a low-pressure boiler, and based on a steam pressure of 28.5 lb. per sq.in. it would require about 5600 lb. of coal per hr., to give the same heating value as the exhaust steam from the 1000-kw. turbine with the same boiler efficiency. In addition 2200 lb. per hr. is required for power production, or a total of about 7800 lb. per hr., while with the back-pressure turbine only 6150 lb. of coal per hour is necessary. This represents a saving of 1650 lb. of coal per hour.

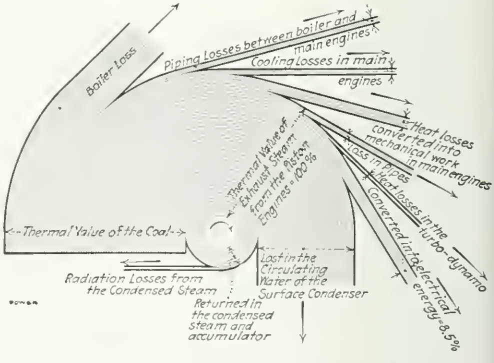

Boiler Loss
Piping Losses between boiler and main engines
Cooling Losses in main engines
Heat losses converted into mechanical work in main engines
Loss in Pipes
Heat losses in the turbo-dynamo
Converted into electrical energy=8.5%
Thermal Value of Exhaust Steam from the Piston Engines=100%
Thermal Value of the Coal
Radiation Losses from the Condensed Steam
Lost in the Circulating Water of the Surface Condenser
Returned in the condensed steam and accumulator
POWER

FIG. 5. HEAT DISTRIBUTION IN AN EXHAUST-STEAM TURBINE

REDUCING TURBINES

It is inadvisable to use the back-pressure turbine when the amount of steam required for heating purposes is independent of that required for power production. For instance, the output in kilowatts may be large when the demand for heating steam is small, and *vice versa*. In such a case the reducing turbine is to be recommended. This is arranged so that a portion of the steam on its way through the turbine may be taken off for heating purposes, the remainder passing along to the exhaust in the usual way.

Fig. 4 demonstrates the heat distribution of a 1000-kw. reducing turbo-generator giving 22,000 lb. of steam per hour for heating purposes. In this diagram $a_1 + b_1$ is usually a constant as also is $a_2 + b_2$. In the extreme case, however, of the whole of the exhaust being used for heating purposes the values of b_1 and b_2 may be 0.

Taking the most ordinary base, namely, a unit of 1000 kw. and giving for heating purposes 22,000 lb. of steam per hour, about 4371 lb. of coal per hour would be required, while for working with a normal condensing turbine, and a special boiler for heating, about 5280 lb. of coal would be required.

Low-Pressure Turbine

This class of turbine is adapted to utilize exhaust steam from reciprocating engines, steam hammers, etc. Theoretically it is possible to get as much work out of one pound of dry-saturated steam at 15 lb. abs. pressure expanded down to 0.85 lb. abs. pressure, as out of one pound of superheated steam at 470 deg. F. and 170 lb. abs. pressure per sq.in. expanded down to 17 lb. abs.

While the reciprocating engine cannot use a higher vacuum than 85 to 88 per cent. with economy, owing to the large size necessary for the low-pressure cylinder and the consequent radiation and friction losses, the steam turbine can utilize with advantage a vacuum as high as 96 to 99 per cent.

The A. E. G. exhaust-steam turbine is, to all intents and purposes, the low-pressure stage of a high-pressure turbine. A steam accumulator may or may not form part of such an installation, according to circumstances.

Fig. 5 illustrates the heat distribution of a 1000-kw. exhaust-steam turbine. The inlet pressure is 15.6 lb. per sq.in. and the outlet (condenser) pressure is 0.71 lb. per sq.in. abs. The steam consumption is 30.8 lb. per kw.-hr.

Mixed-Pressure Turbines

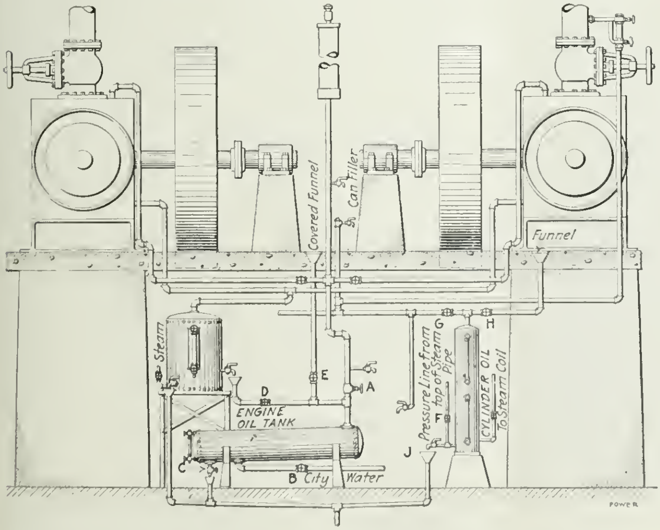
Wherever, owing to the intermittent nature of the work performed by the reciprocating engine, the flow of exhaust steam is irregular, the combined live- and exhaust-steam turbine has a large sphere of usefulness. The turbine for this work is similar to the high-pressure condensing turbine, except that the exhaust steam from the reciprocating engines is introduced into the low-pressure stage. This type of turbine is specially designed so that when the input of exhaust steam is insufficient to meet the load, live steam is admitted to the high-pressure stage. Both live- and exhaust-steam inlets are controlled by an automatic governor to prevent racing.

⁂

Making an Oiling System

By J. C. Hawkins

The oiling system shown and described herewith has given excellent results for years in a power plant having four large and several small engines. The engine oil system consists of a 40-gal. galvanized, closed house tank placed horizontally, with one end about 2 in. lower than the other. This tank is connected to the system at its upper end. There is also a water connection at the lower end, a drain to the sewer, connections to a filter, and a filling connection for putting in new oil, gage-glass, etc.



The Oiling System as Installed

The system operates as follows: The tank is filled with oil and the water pressure of 55 lb. from the city mains admitted at the bottom forces oil up into the system. To fill the pressure tank, the oil valve *A* and the water valve *B* are closed, and the drain valve *C* to the sewer is opened. Then the oil in the filter is drained into the funnel and the valve *D* is opened enough to let the oil run into the tank. When the water has drained out of the tank, valve *C* is closed, and as the tank becomes full or the filter is empty, valve *D* is closed and valves *A* and *B* opened.

While the tank is being filled, the engines get oil from the standpipe in the engine room. This pipe is 6 in. in diameter, 6 ft. long and placed several feet above the level of the engines; it is connected to the system by a 1-in. pipe. There is an air cock at the top which lets the air flow in or out, but it does not allow the oil to escape. This insures the standpipe always being full of oil when the system is in operation. The supply will last until the tank is full and in operation again, when the standpipe will be refilled as the pressure is turned on.

When it is necessary to put new oil in the system, we use a pipe leading from the tank through the engine-room floor with a funnel, the end of which is flush with the floor and fitted with a tight cover-plate when not in use. A spigot is put in the barrel and the oil is drained directly into the pressure tank from the barrel with valves *A*, *B* and *D* closed and valves *C* and *E* open. There is a ½-in. branch pipe from the main oil-supply header to each engine. This comes up over the top of the frame and branches to the crank, the main bearing, the eccentrics and the crosshead, and a separate line runs to the outboard bearing.

All pipe above the floor is of nickel-plated brass, and a suitable regulating valve with a sight feed is placed at each outlet. A faucet is placed below the standpipe in the engine room for filling the oil cans, with a tray to catch the drippings. There is also a faucet in the line in the basement. All oil after running over the bearings returns to the filter through a main return line. The filter is of the usual construction and the trays are submerged in water. The oil passes down through charcoal into a pipe leading to the bottom of the chamber, and returns through hot water passing over the edges of the trays to the reserve chamber. The filter is further aided in throwing down the dirt by heating the water through which the oil passes: this is done by a steam coil in the lower part of the filter.

While the filter is being cleaned, the return oil is drained into a barrel and filtered later. The pressure tank will supply the engines with oil for about 26 hours, and is filled once every 24 hours, the filling requiring about 15 min. The system is so arranged that when it needs cleaning steam can be turned in and the sediment blown out of part of the piping at a time while the plant is in operation.

The cylinder-oil system is operated in practically the same manner as the engine-oil system except that it has a steam coil placed in the pressure tank to keep the oil hot. The pressure for operating is taken from the bottom of the steam line at its highest point and the pressure pipe is left bare to act as a condenser. The pipe is therefore full of water, and the pressure at the bottom of the oil tank is equal to the steam pressure plus that due to a head of water 24 ft. high. This gives plenty of excess pressure to feed the oil. A main header is connected to the tank with ¾-in. branches to all the engines.

Unlike the engine-oil system, there is no standpipe. A 1-qt. hand oil pump is placed on each cylinder, and used when the tank is being refilled with new oil. This is done by closing valves *F* and *G* and opening valves *H* and the drain valve *J*. The oil is put into the tank through a pipe which comes through the floor with a funnel fitted with a tight cover when not in use.

The system is not patented, and any engineer is at liberty to use it with whatever modifications are required to fit the conditions.

⁂

Machinery Designing vs. Repairing Facilities

By Edwin W. Creed

At different times in the writer's experience as an engineer, he has had strong reasons for thinking that some power-plant machinery designers either had little or no experience in practical operation or they did not realize that repairs would ever be necessary.

In one case, the valves of a plunger power pump required frequent grinding. The suction valves were easy to get at, but the discharge valves, because of the close proximity of the air chamber, were almost inaccessible. The valve chambers were closed with a plug, which also acted as a guide for the valve stems. It had a square head on top for turning with a wrench: The difficulty was in removing and replacing the caps as a ratchet socket wrench was required to turn them.

In another plant there was a large vertical, cross-compound engine. After some three years' service the frame head joint on the high-pressure cylinder began leaking badly. To put in a gasket, it was necessary to remove the cylinder lagging, the valve-gear and the piston, and move the cylinder clear of the frame head. It took about a week to do this job and it has been done twice since. As this kind of joint is always likely to leak, it seems that this part might be so designed that the joint could be made over with less work.

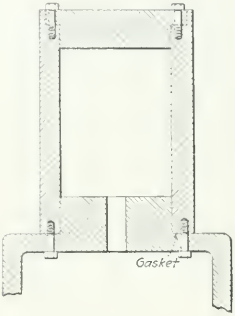


Fig. 1. Design of Old Joint

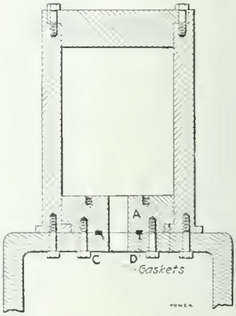


Fig. 2. Design of Proposed Joint

Fig. 1 shows the construction of the frame head and Fig. 2 shows how I think it might be made. It is not necessary to disturb the cylinder to put a new gasket in place. With the piston out of the way, eye-bolts can be screwed into the head block *A*, to lift it out of the cylinder, after removing the stud nuts *C* and *D*. This may not be practical, but it at least shows that there are more ways than one of doing things.

In the same plant, there were three horizontal, cross-compound engines, with the steam and exhaust valves in the heads. Every time the cylinder or piston packing rings were examined, the back head had to be removed. The head joints were so designed that the only way the nuts on the studs could be removed or put back was with a set and sledge-hammer. No wrench I ever saw could be used on them.

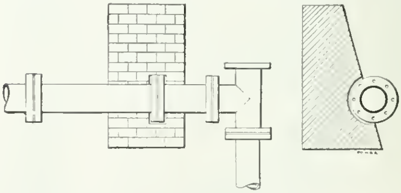


Fig. 3. Two Views of the Pipe and Brick Foundation

I have several times helped to take down closed heaters of the horizontal type, because of leaky tubes. These heaters were in the exhaust line to the condensers and were heavy and difficult to handle. The engines were about 1500 hp. Usually, the coils to be repaired were sent to the manufacturer and one of two things had to be done before the engine could be run; either put back the shell after taking out the coils, which means extra work, or else fit in a length of pipe.

Another difficulty with a closed heater is that the coils eventually become coated with cylinder oil, thus reducing their efficiency. Generally, no provision is made for getting at the coils to clean them; therefore, why not provide against these contingencies when designing a heater? Engineering papers advertise a closed heater which the builders claim has solved these problems, and, so far as I know, they have made good.

Criticism might be made concerning piping job layouts. It is easier to put up new work than it is to make over flange joints, or to make piping repairs after the piping has been in service several years. I recently saw a line of 22-in. flanged cast-iron pipe put up after much time had been spent in measuring and checking up the plans. The pipe and fittings were numbered, and the steam fitters given a blueprint, showing the location of every piece. The plans called for running this pipe so close to the brick foundation of the engines that part of the foundation had to be cut away. At one place the blueprint placed a flange joint opposite an engine foundation, and two men were as many days cutting away enough of the brick to make room for the flanges. Special socket wrenches had to be used to tighten up the bolts.

If that joint ever leaks and has to be made over, there is just one way to do it, after the nuts are well rusted; that is, to break the joints on either side, and lift the pipe out bodily to a position where a man can get all around it.

Fig. 3 gives two views of this pipe and the engine foundation. By changing the positions of the two lengths of pipe, time and labor could have been saved; the joints would then come where they would be accessible. This was suggested to the steam fitter in charge of the job, but he insisted on following the blueprint.

The moral to be drawn is that designers should be men of practical experience or that the designs and plans should be submitted to a thoroughly practical man for approval, preferably the man who will have charge of the operation of the machinery or the plant.

* *

Large Engine Pillow Block Welded

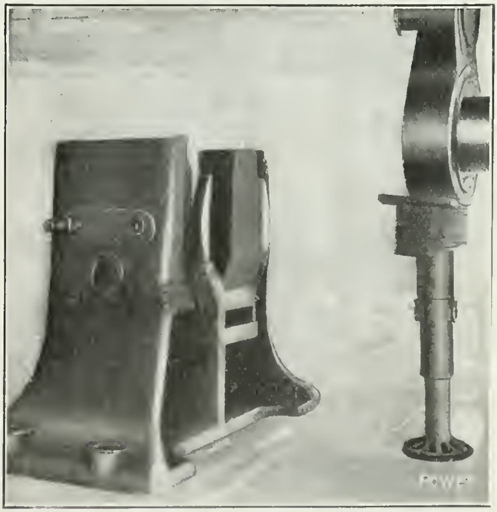
By J. E. Rork

Some engineers are skeptical of welding, while others employ it as a last resort. It is impossible to give a set rule which would cover all emergencies when welding should be used, although it is safe to say that any casting which has had machine work done upon it can be successfully welded. In emergencies where the factor of time saved is of vital importance, oftentimes a large saving can be made by having the repair done by a competent welding concern.

The illustration shows an 8000-lb. pillow block to a 1200-hp. engine which was welded last winter. The break was caused by water getting into the cylinder and the backward thrust breaking off the back of the pillow block. This was a serious accident, it being impossible to obtain a new block without long delay; as it was, it looked like a long shutdown of the entire plant.

The welding was done at the mill, it being more feasible to move the welding equipment than to attempt to move an 8000-lb. casting any distance. A beam track was erected just outside the engine room and an inclosure made with canvas. The casting was chipped from both sides, leaving a web in the center, the two parts forming an "X" when placed together. The broken back was held in place by heavy bars of iron which were left on during all the welding. A temporary furnace was built around the portion to be welded, and the casting was preheated by two oil burners.

Two complete welding outfits were used on the job and about 1000 ft. of oxygen was consumed before the weld was finished. As saving time was the main factor in this repair, welding was continued day and night for 36 hr. The welding was finished in the evening, after which the casting was again heated, banked and allowed to cool over night. This precaution was taken to remove all the internal strain which might be caused by uneven cooling. The next morning the pillow block was put into place and the engine was soon in operation. This repair has stood a test of ten months' service and the engine is in operation today.

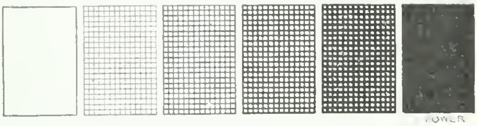


Showing Weld in Pillow Block

This is only one instance in which welding has proved a sure saving of much money and unnecessary delay. The welding of large pieces is finding favor among engineers and is an economical process in a breakdown.

Convenient Ringelmann Smoke Scale

The ordinary Ringelmann four-scale chart for grading the density of smoke measures 8x24 in., and must be posted about 50 ft. distant from the observer. For accurate reading this is perhaps the best size of chart and the proper distance, but the Hamler-Eddy Smoke Recorder Co., Chicago, Ill., is issuing a chart, illustrated herewith, which is $\frac{3}{4}$ in. high and $3\frac{1}{4}$ in. long, printed on a $2\frac{1}{2}$x$4\frac{1}{4}$-in. card. A reading may be taken at arm's length. It is convenient to carry in the pocket, and for ordinary use is fairly accurate.



Actual Size of Chart to Be Used at Arm's Length

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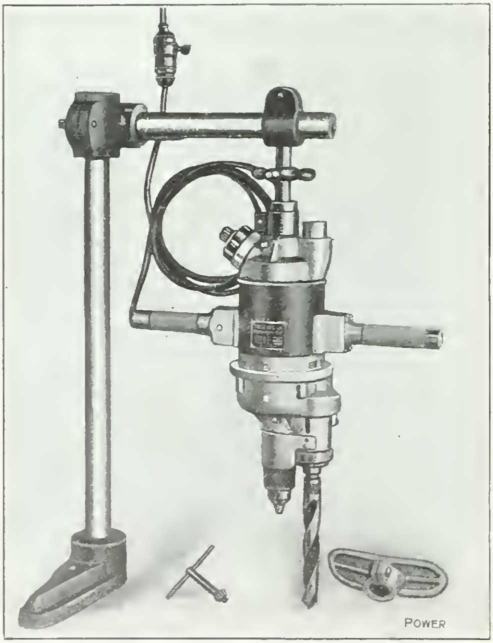
Stow Portable Drilling Machine

The two-spindle, two-speed drill illustrated, is designed for use as a portable machine. The smaller spindle is fitted with a Jacobs chuck for holding straight-shank drills up to $\frac{1}{2}$ in. in size, and has a speed of 450 r.p.m. The larger spindle takes a Morse taper drill up to $\frac{3}{4}$ in. and has a speed of 225 r.p.m. A chuck can be attached to the larger spindle if desired.



Portable Drilling Machine

The two-spindle arrangement gives the tool a wide range of application, and the spindles can be reversed for tapping operations. This machine, manufactured by the Stow Manufacturing Co., Binghamton, N. Y., is furnished for both alternating and direct current, the electric connection being arranged to fit any ordinary lamp socket.

⁂

Universal Packing Hook

Every engineer realizes the difficulty which he has encountered in using the ordinary design of packing hook where space is restricted between the crosshead frame and the stuffing-box. This difficulty seems to have been eliminated to a great extent by the type of packing hook illustrated herewith; it consists essentially of a universal joint between the worm end and the handle.

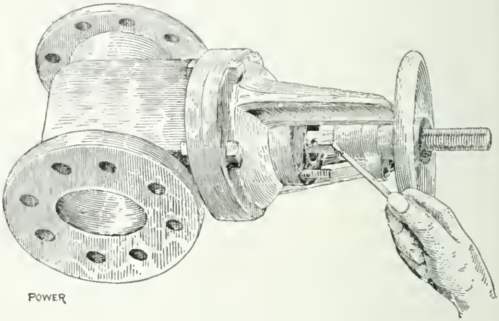


Fig. 1. Using Tool on Gate Valve

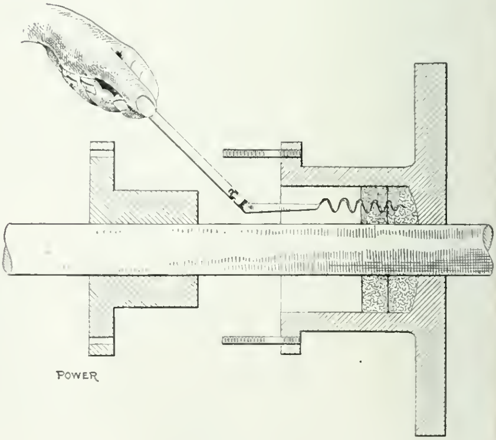


Fig. 2. Tool as Used with Engine Stuffing-Box

The hook, which is manufactured by the Universal Tool Co., Box 756, Waterbury, Conn., can be used in removing packing from any type of stuffing-box on engines or pumps, several sizes being included in each set. Fig. 1 illustrates the hook as used with a gate valve; Fig. 2 shows how it is used in removing packing from the stuffing-box of an engine or pump.

Editorials

Power-Plant Legislation

The United States has less legislation relating to boilers than any other industrial country—and more boiler explosions.

The opinion that that government governs best which governs least has met with too general an acceptance.

The right of a property owner to do as he pleased with that which was his, leaving to those who were injured reparation only through the courts, has been carried too far.

In our table of boiler explosions, printed in the issue of June 30, there were mentioned, all told, 500 boiler accidents, including tube ruptures and blowoff failures, many of which resulted in fatal injuries. Officials of three different boiler-insurance companies announced not long ago that their losses from tube failures, etc., amounted, in the aggregate, to more than those from complete explosions. In the five hundred accidents of which we were able to get any news, 171 people lost their lives and 387 were injured. Our reports covered the property loss in only 163 of these accidents, but this totaled $213,644. It is readily conceivable that the total loss in all the accidents that occurred would be very far in excess of that figure.

Most of these disasters were preventable by the exercise of ordinary human foresight and intelligent supervision. Had skilled inspection and safe operation been imposed, the saving would have been worth many times what it cost.

For thirty-odd years POWER has been urging legislation to this end. It has been an up-hill fight. Users of boilers and employers of engineers saw in it only an attempt to place upon them burdensome restrictions, to subject them to the extortions of another set of grafting public officials and to curtail their labor market. On the other hand, although their leading organization, the National Association of Stationary Engineers, has actively advocated such legislation, many operatives in charge of the boilers and engines have opposed it through their fear of being unable to qualify before a board of examiners and obtain licenses.

Against these influences and the general inertia, such laws were procured in a few states and cities, and finally Massachusetts, under the impetus of a particularly disastrous explosion, adopted laws which provided not only for the inspection of boilers and the examination of the men who should run them, but for a "Board of Boiler Rules" which specifies how boilers shall be constructed, what material may be used, how the accessories shall be connected, etc

Like legislation has been adopted by Ohio and Detroit, and is under consideration by the legislatures of many other states. Some of the Canadian provinces have also established boards of boiler rules, and others of our own states and cities have less comprehensive regulations governing the pressure allowable with certain construction. Two aspirants for degrees in one of our Western colleges have demonstrated the impossibility of making a boiler which would be acceptable in all of nineteen states, provinces and cities having such regulations.

This condition, which promises to become more onerous and complicated through the extension of such legislation and the adoption of still other incongruous regulations, is a serious one for the boiler makers. Each boiler must be built with a knowledge of where it is to go, and must stay there. Boilers cannot be built for the general trade, nor for stock, and various kinds of plate and material must be kept on hand to meet the views of different boards and inspectors. Furthermore, the contractor or other nomadic user of boilers may find his outfit, designed to meet the requirements of one locality, entirely outlawed in another.

Recognizing the growing importance of the matter, the American Boiler Manufacturers' Association, at its New Orleans meeting in the spring of 1912, adopted a resolution urging uniform boiler legislation in all states. The National Association of Tubular Boiler Manufacturers, under the solicitation of Thomas Durban, of the Erie City Iron Works, has done still more aggressive work in this direction, having held a meeting at Pittsburgh for this special purpose, at which were present boiler makers and inspectors from all over the country; a later meeting in Chicago especially for consultation with the steel manufacturers, and having opened correspondence with the governors and the leaders of legislation in all of the states, urging the necessity of legislation concerning the construction, installation and operation of boilers and the desirability of uniformity in such legislation.

If there is to be a great forward movement along this line, it is essential that it should be intelligently directed. The legislator, knowing little of the subject, torn, twisted and importuned by conflicting interests, should have something to which he can turn as a guide and standard; some proposition the adoption of which is so obviously the thing to do that his warring constituents will have no leg to stand upon.

The one conspicuous logical authority for him to look to is the big national professional society which is concerned wtih such matters, the American Society of Mechanical Engineers. And this society, too, is alive to the situation and has already taken action which will enable it to respond fully and intelligently to this demand upon it.

A committee consisting of John A. Stevens, consulting engineer and ex-member of the Massachusetts Board of Boiler Rules, representing the users; William H. Boehm, of the Fidelity & Casualty Co., representing the insurance interests; Profs. R. C. Carpenter, of Sibley, and E. F. Miller, of the Massachusetts Institute of Technology, representing the scientific side; Charles L. Huston, vice-president and works manager of the Lukens Iron & Steel Co., representing the steel manufacturers; Past-President E. D. Meier, president and chief engineer of the Heine Safety Boiler Co., and Richard Hammond, president of the Lake Erie Engineering Works, representing the boiler makers, has been appointed "to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of the same in service." This committee has prepared a tentative report including not only boiler rules and specifications, but, under the "care of same in service" clause, forms of law which will put the proposed regulations into effect. Over two thousand copies of this report have been sent out to specialists in the lines affected for criticism and suggestion.

A hearing will be held at the Engineering Societies Building, New York, on September 15, to which all in any way interested are invited. Discussion should be sent to the committee at the headquarters of the American Society of Mechanical Engineers, 29 West 39th St., by August 10. Much such material has been already received, and it is hoped that the report as it goes to the December meeting of the society will be the embodiment of the best experience and wisdom of the nation: for besides the committee which has prepared the tentative report and the specialists who have been invited to discuss it, everybody having any interest in or ideas upon the subject is invited to present a discussion in writing and to be present if possible at the hearing.

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Duty First at Salem

On Friday afternoon, June 25, half the industrial and adjacent residential district of the historic city of Salem, Mass., was wiped out by a conflagration. Factories, churches, schools, homes, stores—poles, overhead wires, stock houses, garages and buildings to the number of about one thousand melted away in the flames which were swept back and forth through the town by the veering winds.

Near the center of the fire the generating station of the Salem Electric Lighting Co. awaited the onslaught of the conflagration. The company's offices and stock building, a stone's throw away, caught fire; the advancing wall of flames reached the opposite shore of South River, a hundred feet distant from the plant; and on the east and south, buildings and coal piles in their turn fell prey to the fire demon. In a few minutes the station was surrounded with a roaring fury of heat and leaping light; sparks flew against the walls and windows, brands struck the roof and flying oil from an exploding tank on adjacent property beat against the windows.

Inside the building, five men waited for the storm to pass. The windows were of wired glass; the walls were brick, a foot thick; the roof was of tile construction, with tar and gravel top. The distribution system was cut off, but the operating force kept steam up and ran the exciters. They played streams of water against the only two wooden doors in the building, and they saw to it that every window and door was shut to the limit of tightness. The water pressure, normally fifty pounds, was down to seven; but the boiler-feed lines were kept going. The coal conveyor belt became ignited and carried the flames into the coal pocket, but they extinguished them. In the fierce draft, sparks flew through cracks into the boiler room, the smoke from without thickened the air almost to suffocation, but the plant was manned. Gradually the heat subsided, enabling the outer air to be let in more freely, the doors were opened, and at two o'clock in the morning the United States flag rose to the top of the building amid the cheers of thousands of onlookers, who thus paid tribute to the undaunted courage of the men behind the throttle and the slice bar—men who, like thousands of others on land and sea, listened to the call of duty when it came, without retreating, and with honor to their occupation.

That this brand of courage is to be expected throughout the engineering profession and that the faithfulness of the men at the plant of the Salem company is typical may well challenge the admiration of those who take little thought of the qualities which have made the American power-station operator what he is today.

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Municipal Coalition to Avoid Utility Extortion

The way to avoid an exorbitant charge for a service is to do it oneself. This applies to communities as well as to individuals.

If water, gas, electricity, transportation are not furnished satisfactorily and at reasonable rates by the present purveyors, it behooves a community to furnish them itself. The reasons why most communities do not do so are the distrust of municipal ownership, which has been created at enormous expense by those whose interest is to prevent it, and the paper walls which the same interests have erected against the communal undertaking of such enterprises.

Not so many years ago, the proposition that the rates of public-service corporations be subject to governmental regulations was decried as radical and revolutionary in the extreme—a veritable imposition upon the rights of property. Today, in nearly all the states, the activities of public-service corporations are controlled by public-service commissions, which not only fix rates but control the issue of securities and decide whether a company may or may not do business in a given locality. In some states it is necessary for a city to obtain the sanction of such a commission before its people can, in their collective capacity, perform their own public services.

The decisions of these boards seem to indicate that they have sometimes been unduly impressed by the able arguments presented by the best talent which the united interests can buy, untempered by any such adequate presentation of the people's side of the case.

There is now on foot a movement to unite the cities in an effort to procure an equally able presentation of their side of the story. Mayor Rudolph Blankenburg of Philadelphia has issued an invitation, in which he is joined by Mayors Mitchel of New York, Harrison of Chicago, Baker of Cleveland and Shroyer of Dayton, to the mayors of all cities, large and small, to meet in conference in Philadelphia, in the autumn, to discuss the various phases of the public-utility problems as affecting the people, and how they may best be dealt with.

It has been suggested that a Bureau of Public Utilities Research be organized, which shall equip itself to give to the cities the same able assistance which the public utilities companies' associations give to the public utilities companies, thus in effect constituting an offensive and defensive alliance among the cities similar to that existing among public-utility corporations.

Correspondence

Auxiliary Economy in Steam Power Plants

Mr. Starkweather's position regarding the rating of closed heaters, as published in the June 9 issue, page 827, is well taken, but if auxiliary economy is the object, why use the closed heater at all?

It is true that, with a constant of transmission of 250 deg. per sq.ft. per hour per degree difference in temperature, the water may be heated to within 5 or 7 deg. of the steam temperature. As each 10 deg. in the temperature of the feed water ordinarily represents about 1 per cent. of fuel, it might appear that only one-half or three-quarters of 1 per cent. were lost. However, if the amount of exhaust steam available is limited at times, as is usually the case, the loss in economy through the use of a closed heater may amount to 1 or 1½ per cent., because the steam condensed in heating the water in a closed heater is ordinarily wasted, whereas, in the open heater it is conserved, saving the heating of that much cold water.

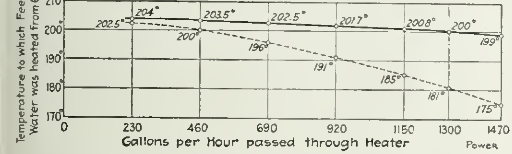

Diagram Showing Graphically the Result of Tests of a 1300-Gal. Heater Using Exhaust Steam

In one case it is estimated that at normal load there would be 178,000 lb. of feed water to be heated and that the supply of exhaust steam would vary from 18,000 to 28,000 lb., while at 50 per cent. overload, with 260,000 lb. of feed water, the supply of exhaust steam would vary from 21,000 to 31,000 lb. per hour. Under the normal load condition, with 18,000 lb. of exhaust steam available, the open heater would give a temperature of 195.5 deg. F., while the closed heater would give only 182.9 deg., a loss of about 1¼ per cent. in fuel economy. With 28,000 lb. of exhaust available, the open heater would give theoretically, and practically also if provided with proper heating trays, 212 deg., whereas the closed heater, assuming 0.7 sq.ft. per horsepower and a coefficient of 300 instead of the 250 stated by Mr. Starkweather, could, at the best, give only 210 deg.

Under the overload conditions, with 21,000 lb. of exhaust available, the open heater would give 173.1 deg., and the closed heater only 163.1 deg., while with 31,000 lb. the open heater would give 212 deg. and the closed heater only 200.3 deg.

The capacity in both cases is based on the supposition that no steam is wasted. This condition can be secured with an open heater if properly installed, and is ordinarily guaranteed by the makers. With a closed heater, on the other hand, it is difficult or impossible to secure the maximum transmission unless there is sufficient exhaust-steam surplus to keep the heater free of an accumulation of air. There is always some air in the exhaust steam, and if all the exhaust steam supplied to the heater is condensed, there will be a continual accumulation, bringing about an air-bound condition similar to that of a surface condenser operated without an air pump.

In closed heaters as ordinarily designed, this condition exists even when there is considerable surplus of steam, as shown in the accompanying diagram, giving the results of a test on a closed feed-water heater of the high-velocity type. The full line represents the higher temperatures obtained when reducing the quantity of feed water and maintaining the flow of exhaust steam at half the weight of the listed water capacity of the heater. In other words, about three times as much exhaust steam was being passed through the heater as should have sufficed to heat the feed water up to 212 deg. The dotted line gives the temperatures obtained with only 2300 lb. of steam per hour, and shows that when only the theoretical amount of steam required to heat the water is supplied, a temperature of only 175 deg. is reached.

It is true that the waste of the condensed exhaust steam could be avoided by fitting the closed heater with an oil separator, as has been done in some cases, and it also protects the tubes of the heater from grease accumulations, although it does not prevent scale, both of which frequently cause considerable loss in heat transference in such heaters. If this is done, why not omit the tubes altogether and make an open heater of it? Properly designed and installed oil separators have proved successful, and water condensed from steam purified by such separators, or heated by direct actual contact therewith, is used for ice making, dyeing, laundering, etc., where the least trace of oil would be inadmissible

Other advantages also entitle the open heater to consideration, as, for instance, its action in driving air and other gases out of solution in the water as it is sprayed through the steam bath of the heater. Recent investigations have abundantly established the fact that corrosion in boilers does not take place in the absence of dissolved air; further, where the piping, the turbine casing and the condenser are carefully erected, the air dissolved in the feed water is about the only source of air in the condenser. With absolutely air-free condensers, the problem of maintaining high vacuums would be easily solved, with almost any kind of air pump or even none at all.

The breaking up of bicarbonates by heat also brings about the precipitation of a considerable portion, which is beneficial in the case of the open heater, as the sludge settles in it instead of going to the boiler; it is detrimental, however, in the closed heater, as the formation of scale on the tubes interferes with heat transmission. The open heater is available as a return tank or hotwell for the reception of live-steam trap discharge and other water supplies about the plant suitable for boiler feeding.

and also acts as an automatic makeup water regulator, neither of which is done by the closed heater.

The open heater has been brought to such perfection and utility—as witness the use of extra-large separators for purifying the surplus exhaust steam for heating systems, cooking kettles, low-pressure turbines, drying systems, etc., and the recently introduced metering heaters. for measuring the boiler feed—that a return to the closed heater seems a step backward.

There is one place, however, where the closed heater may be used as a primary heater in the exhaust line between the engine and the condenser. This, however, is being discarded because of the extra resistance introduced, and because recent designs of condensers deliver the condensate nearly at steam temperature.

William B. Campbell.

Philadelphia, Penn.

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Value of Laboratory Coal Testing

A number of Power articles, as well as an editorial, on the value of laboratory coal testing, have interested me. Laboratory tests alone are of but little service, and purchasing coal on the B.t.u. basis alone, or the B.t.u. and ash basis, particularly by proximate analysis, is unwise because it does not give any real information as to what the coal will do when burned under the boiler.

Different types of boilers and settings will burn to the best advantage coal of only one character, each boiler and setting being adapted to a coal having certain fairly definite characteristics. It is advisable, therefore, to experiment with different coals under the boiler, and determine which one will evaporate the most water. Next, take the best sample, have it analyzed, and draw up specifications for coal which will come as close to this analysis as is possible.

Coals vary widely in moisture, volatile matter, fixed carbon and ash. For the majority of boilers as now set—i.e., too near the grates—coals which run the lowest in moisture or are high in fixed carbon are the most satisfactory.

The accompanying table is of samples of coals ranging in heat value from 14,701 to 13,825 B.t.u. The volatile matter ranges from 36.77 to 15.8 and the fixed carbon from 75.83 to 55.14; the latter, No. 10, is low in moisture, comparatively low in ash, but high in volatile matter. This coal with the ordinary low setting will not give nearly as good results in evaporation as No. 4, which has 75 per cent. fixed carbon and but 15.8 per cent. volatile matter.

Order of Value by B.t.u.	B.t.u.	Moisture	Volatile Matter	Fixed Carbon	Ash	Order of Volatile Matter
1	14,701	2.80	17.10	74.80	5.30	12
2	14,672	1.63	17.17	75.83	5.86	11
3	14,522	3.37	21.80	70.74	4.09	9
4	14,499	1.10	15.80	75.69	7.41	14
5	14,470	3.05	31.65	60.82	4.48	3
6	14,465	2.00	17.52	74.10	6.33	10
7	14,436	3.74	31.04	61.31	3.91	4
8	14,425	2.96	22.74	69.29	5.01	8
9	14,279	3.51	16.82	73.04	6.63	13
10	14,107	1.75	36.77	55.14	6.34	1
11	14,105	2.86	23.25	58.08	5.83	2
12	14,074	3.23	26.16	63.90	6.71	7
13	14,069	1.48	28.58	61.55	8.39	6
14	13,925	4.08	28.61	60.73	6.58	5

The reason is that, with the present character of setting, with grates so near the boilers and with hand firing, the volatile matter is driven off unburned, carrying with it a considerable percentage of fixed carbon in the form of smoke. Therefore, in addition to the B.t.u. test, the specification should state the minimum of fixed carbon or the maximum of volatile matter, as well as the percentage of ash and moisture. In no better way can the purchaser be assured that the coal bought will work satisfactorily.

This was plainly demonstrated in a large plant where coal was bought on a straight B.t.u. basis. The coal was sampled by an expert and carefully analyzed. In many samples the B.t.u. ran above the guarantee, and a bonus was paid, but the evaporation fell off. The owners were seriously "up against it." Fortunately, before this had gone on long, they again called in the engineer who had written the specifications. The coal dealers claimed that they were furnishing all that was called for and demanded the bonus. The engineer, however, pointed out a clause in the contract, which had been put in largely as an afterthought, covering the minimum amount of fixed carbon which would be accepted; the coal furnished had run considerably under this percentage. Thereafter a different coal was sent, which met the needs of the plant fully.

Of course, it must be remembered that coals vary in different localities in volatile matter, fixed carbon, ash and moisture, but each will burn satisfactorily with some certain type of setting. Therefore, when installing a plant, the first thing to do is to determine the character of the coal which is in that market, and then use a boiler and setting adapted to such coals. This point being covered, a specification can be drawn which will describe the coals desired, and thereafter economy is assured so far as it can be obtained through the proper purchase of coal.

Henry D. Jackson.

Boston, Mass.

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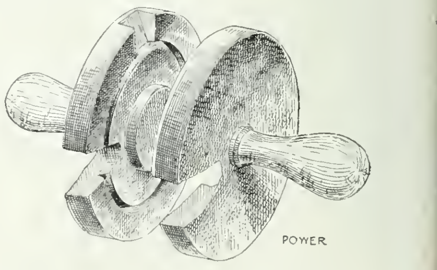
Lead-Gasket Mold

A mold we use for forming small lead gaskets, I think, is much better than the plates described by J. C. Hawkins in Power of April 28, p. 604. It is light and easy to handle, and one man can pour twice the number of gaskets with it that two men can with the plates. One of the handles shown is to be clamped in a vise.



Mold for Small Gaskets

We have used them with satisfaction on Heine boilers carrying 150 pounds pressure. The gaskets are easily removed from the mold with the aid of a screwdriver.

C. L. Spurrier.

Elyria, Ohio.

Some Data on Slack Belts

That a slack belt has decided advantages over a tight-running belt has been repeatedly stated, but data relative to the reliability and pulling power of the former have not been given.

Here are some figures taken from eight actual installations where belts are run with considerable slack. They prove that tightness is certainly not always necessary; I do not believe it is ever necessary. The trick in belt operation is to keep the belt flexible and soft so that good contact is always made with the pulleys.

Width of Belt, In.	Kind of Belt	Horsepower Transmitted	Tension on Pulling Side, per Inch of Width, Lb.
10	Canvas	85	90
12	Leather	82	92
19	Leather	90	110
14	Leather	100	113
6	Leather	25	114
20	Leather	100	117
10	Cotton	70	127
16	Painted canvas	300	264

Note, particularly, the last column on the right. These pulling tensions are much higher than is usually attained with belts that are kept tight on the nonpulling side, and, better still, these slack belts run smoothly, giving no trouble whatever; they pull peak loads with ease.

The looser the belt, the greater is its arc of contact, and therein lies one of the greatest advantages. These data are a direct contradiction to the declarations made by many that "belts well proportioned for the work required of them need tightening at intervals of two to six months."

S. F. WILSON.

New York City.

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Electrifying Furnace Air

In the June 16 issue, A. P. Conner suggests that in cases where mechanical draft is used, a much greater efficiency could be obtained by electrifying the air before it goes to the blower. He states that this would cause the air to become ozone, which, in contact with the fire, would combine much more energetically than ordinary air. It may be interesting to learn more about this little-understood ozone.

Ozone was first noticed by Van Marum, in 1785, as a peculiar smelling gas formed during an electric discharge. Schoenbein named the gas and noted its powerful oxidizing properties. Ozone is a modification of the element oxygen.

The smallest particle (molecule) of ordinary oxygen capable of existing alone consists of two oxygen atoms, while the molecule of ozone has three. As the oxygen atoms in ozone are not as firmly held together as those in ordinary oxygen, ozone is readily broken up or decomposed by many substances. In the presence of moisture nearly all metals except gold and platinum decompose ozone, and are themselves oxidized or corroded. Ozone is *partially* decomposed into ordinary oxygen at room temperature and *completely* decomposed if heated to about 570 deg. F. Ozone has other interesting properties: It is blue in color; has an odor somewhat resembling that of bleaching powder, and one part in 500,000 parts of air can be detected; it acts on the respiratory organs, making breathing difficult, and small animals die quickly when they breath it.

The use of ozone for improving furnace combustion seems more fanciful than practical. Even assuming that any of the "ozonizers" on the market are capable of cheaply and completely changing the oxygen of the air to ozone, it is very doubtful whether any ozone as such would ever reach the furnace fires. Unless all the moisture in the air was eliminated, the ozone in the presence of moisture would have a corroding action upon nearly all metals with which it came in contact, and would itself be decomposed.

Since ozone is completely broken up at about 570 deg. F., which is well below combustion temperatures, it is obvious that before it reached the fire it would be transformed into ordinary oxygen and the electrical energy which had been consumed in its production would have been wasted.

WILLIAM A. DUNKLEY.

Atlantic City, N. J.

⁂

Baffling Water-Tube Boilers

In the May 19 issue, in the article on "Baffling Water-Tube Boilers," the information contained is valuable, but it might be misleading from the fact that it applies to natural or induced-draft installations only. The areas given therein will not prove successful from an efficiency or capacity standpoint on forced draft, being especially inefficient on overload capacities.

That the same areas will not apply to forced draft can be determined mathematically as well as by actual test. Consider, for instance, the release areas on the Stirling boiler. Other conditions being equal, the ratio between any pair of release areas would be determined by a compound proportion, the first terms of which are the ratio at corresponding points of vacuum or draft measured by water gage and the ratio of the volume of gases at the same points due to difference in temperature.

It may be assumed for all practical purposes that the latter ratio is the same in both natural- and forced-draft installations, so that the area of release openings may be considered inversely proportional to the water gage at or near the release areas. If the vacuum or draft at each release of a Stirling boiler beginning at the release nearest the stack is represented by the letters V_1, V_2 and V_3 and the vacuum over the fire by V_4; and the corresponding release areas as R_1, R_2 and R_3, the following proportion will be obtained:

$$V_1 : V_3 : : R_3 : R_1$$

In forced draft V_4 can be considered zero, as in modern forced-draft plants it is held down to from 0 to 0.05 in. In natural-draft plants the stack pull must be sufficient to overcome the fuel-bed resistance and V_4 becomes, say, 0.25 in. The vacuum at the three releases would then be: $V_1 + 0.25$ in., $V_2 + 0.25$ in., and $V_3 + 0.25$ in. The proportion for the release area would be,

$$V_1 + 0.25 : V_3 + 0.25 : : R'_3 : R'_1$$

It is evident that the addition of a constant to each term of a ratio changes the ratio, and, therefore, the ratios of the release areas in natural draft are not the same as in forced draft. The addition of a constant also decreases the fourth term of the proportion, which also demonstrates that the release areas nearest the stack on forced draft should be reduced and that the passes nearest the grates should be increased, over the usual practice with natural draft.

This result has been demonstrated in practice many times and the release areas that prove successful by experiment with natural draft are unsuccessful with forced draft. Anyone installing or using forced draft and endeavoring to get results by using ratios of openings given in the article mentioned would have serious difficulty.

J. H. Dietz.

Cleveland, Ohio.

[In this article Mr. Monnett referred to natural draft only. What he has to say concerning forced and induced draft will appear later in the series.—Editor.]

Blowoff Pipe Failures

The suggestion given by Basil Copping, on page 786, June 2, about the cause of the blowoff fracture does not look good to me. No doubt, opening the cocks disturbed the scale slightly, or that when closed the scale blockade gave away suddenly and was forced into the practically empty pipe along with water. It is simply a case of water-hammer.

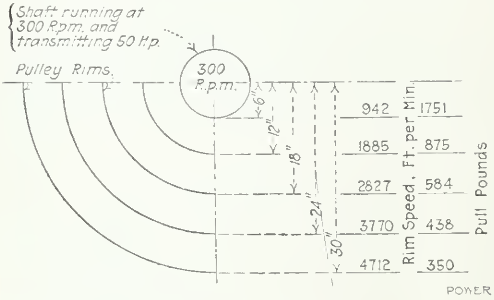
An interesting blowoff break occurred here on June 7 during a heavy rain storm, with a lot of lightning and thunder thrown in. Several people noticed what looked like a ball of fire break and scatter right over our smokestack; at the same instant the blowoff pipe on one of the boilers gave way. There was 70 lb. pressure on the boiler at the time and it made things lively; steam and cinders were blown about the boiler room. The blowoff pipe was later examined and found to be bent and twisted. The end, which was outside of the boiler setting and not in contact with fire or heat, was fused and twisted badly, it was also red, as if it had been hot and part of the end was fused. Nothing else was damaged. The boiler inspector and I agree that it was caused by the lightning, but why it should come down the chimney, strike the blowoff pipe and touch nothing else, beats me.

John Thorn.

Toronto, Ont., Canada.

Belt Pull on Bearings

A point that is frequently overlooked when selecting pulleys is that the larger the pulley, the less will be the pull on the bearing and belt in transmitting a given power, the speed of the shaft being constant.



Belt Speed and Pull

For example, a 12-in. pulley transmitting 50 hp. at 300 r.p.m., the belt speed would be about 943 ft. per min., and the pull (assuming zero tension on the slack side) 1750 lb. With a 24-in. pulley the speed would be 1886 ft. per min., and the pull 875 lb., and so on, as shown in the diagram. It is best not to use either extreme because, where the diameter is small the pull is too great, and where the diameter is excessive, the velocity is too great.

W. F. Schaphorst.

New York City.

Oil Explosion in an Air Compressor

I fed a lot of oil into a two-stage, tandem air compressor to be sure I would get enough into the cylinder, but I used too much, and it exploded in the high-pressure air cylinder. No damage was done to the air compressor, but the high-pressure air line ruptured in five different places. Small pieces of copper pipe were found all over the building and some went through the roof. Fortunately, no one was injured.

John J. Oelrich.

Amadoville, Ariz.

Commutator Insulation

Pitting of the mica insulation between segments of commutators leads to all sorts of trouble. The better the insulating material, the less the danger of pitting, although the best will pit to some extent. This results in a flash-over, burned-out coil or other commutator trouble.

To overcome this, I use a paste made up of powdered mica, plaster of paris and orange shellac mixed together in the form of an easily workable mixture. To apply, first clean out all the burned insulation and scrape until the mica can be seen; then press the paste into all the crevices thoroughly without entrapping air. Allow the work to stand for a short time, and then scrape with sandpaper until the commutator is smooth, and the machine is ready.

The drier this paste, the better the insulation. Therefore, to be sure of a good job, bake or heat it with a torch until dry. It will keep a motor or generator running as long as there are no burned-out wires, and will often save coils from being burned out. The best tool for cleaning out the burned mica is had by grinding a hacksaw blade to about the thickness of the insulation.

I have tried this for years and have found it to give good satisfaction.

F. A. Grohsmeyer.

Chicago, Ill.

Frost Covered Generator

In answer to E. R. Pearce's letter in the June 9 issue, I do not believe that the insulation was affected. There is always a little moisture in the engine-room coming from the crank cases of two Westinghouse engines, and this collects in the generator casing as soon as the temperature goes below freezing.

The handhole plates were taken off and no moisture or frost could be found inside, while the coils were of a higher temperature than the casing. As the load increased to one-half or better, the frost started to melt off. The field excitation, so far as could be ascertained, was not impaired and is usually better in cold weather than in summer.

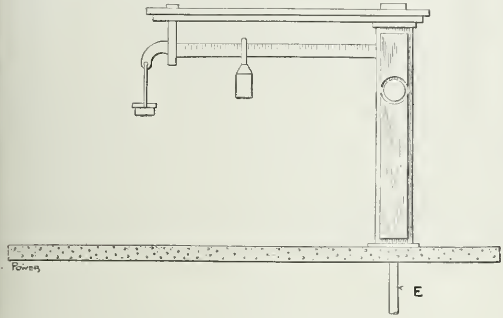
F. E. Albrecht.

Lisbon, Ohio.

Scale Beam in the Engine Room

That the coal record of many of our smaller plants is not accurately kept is due to not having the proper weighing facilities.

The idea shown here comes from one of our engine rooms. The scale beam can be placed in the engine room, where the chief or the engineer in charge can read and record the weight of the coal as it is delivered. The scale beam can thus be kept in a better condition, and the engineer does not have to leave his post to ascertain the correct weight. Many of our plants could be thus equipped by simply lengthening the link rod *E*.



Scale Beam in Better Location

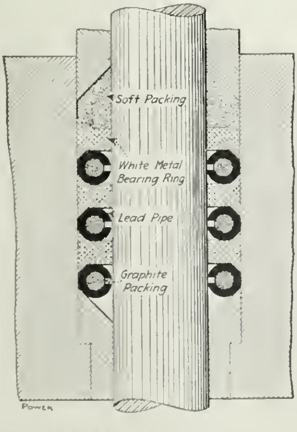
C. R. McGahey.

Baltimore, Md.

⁂

Rod Packing

The illustration shows a section of an easily made packing which will be found serviceable for the steam ends of direct-acting pumps and compressors. It has two parts—i.e., heavy lead-pipe rings and bearing rings which also act as wedge blocks. The lead pipe is cut a little shorter than the circumference of the rod, then one end is plugged with a disk of lead and soldered up, and the tube rammed tight with powdered graphite, which has had enough cylinder oil added to make it plastic.



Metallic Packing

When the ring is full a disk is soldered into the other end or the end beaded over the disk (the presence of oil makes soldering difficult). A number of 1/8-in. holes are drilled on the rod side of the packing at about 3/4-in. centers so that the lubricant will come out on the rod.

The bearing rings must be in halves and may be left rough on the sides, the edges being fitted to the rod and stuffing-box, where it will give the rod a little support. The best mixture for the rings is composed of 75 parts lead, 5 parts tin and 20 parts antimony, but pure lead may be used with success. At the outer end of the gland a turn of ordinary soft packing is put in.

It is also advisable to drill a few holes in the bearing rings to enable them to be drawn out with an ordinary packing hook. This packing is suitable for any saturated steam pressure in ordinary use and for low superheats so long as the total temperature does not exceed 475 deg. F.

The sketch shows the packings in place before screwing up the gland, after which, of course, they are distorted.

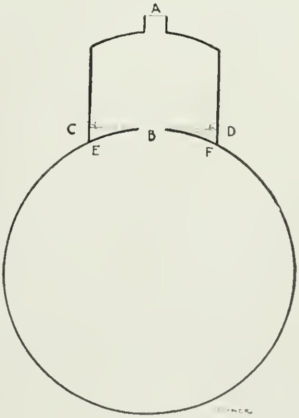
E. R. Pearce

Rochdale, England.

⁂

Water Lodged in Boiler Dome

A boiler having a dome mounted as shown in the sketch had a 4-in. outlet at *A*. A 6-in. hole was cut in the boiler shell at *B* to allow the steam to enter the dome. When the boiler was under pressure, and was not in use, a cracking noise in the dome could be heard. The steam would be very wet when the valve was first turned on.



Where the Water Lodged

After the boiler cooled down, pockets of water were found at the points *C* and *D* in the dome. To drain these pockets, holes were drilled at the points *E* and *F*, and the trouble stopped. Evidently the heat in the steam failed to evaporate the water in the dome.

Charles G. Buder.

St. Louis, Mo.

Engineers' Study Course

Elementary Mechanics—XVII

Last Lesson's Answers

71. The length of the crank OA (Fig. 62) is 6 in. In one revolution of the engine the crankpin A will move a distance equal to

$$2 \times 3.1416 \times 6 = 37.7 \text{ in.} = 3.14 \text{ ft.}$$

The velocity of the crankpin in feet per minute equals

$$300 \times 3.14 = 942 \text{ ft.}$$

Let the line AC drawn at right angles to the line OA, represent this velocity. Extend the line of the connecting-rod BA and from C drop the perpendicular CM to AB. Then the line AM will give the velocity with which the connecting-rod is moving at the given instant and, since the rod is assumed rigid, the velocity of B (which represents the crosshead) must equal the velocity AM of the point A. The velocity of the crosshead is the horizontal component of the velocity of the connecting-rod. Therefore, draw the line AN horizontal, and from M drop the perpendicular MN to the line AN. The numerical value of the velocity AN may be found as follows:

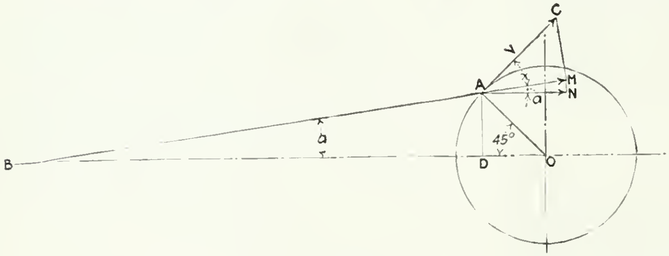


Fig. 62.

$$\sin a = \frac{AD}{AB}$$

and

$$AD = OA \times \sin 45 \text{ deg.} = 6 \times 0.707 = 4.24 \text{ in.}$$

or

$$\sin a = \frac{4.24}{30} = 0.14$$

hence angle a = 8 deg. (approx.). By construction the angle CAN = (angle a + angle x) = 45 deg. Now, since the angle a equals 8 deg. it must be evident that the angle x equals (45 — 8) = 37 deg.

But

$$AM = AC \times \cos 37 \text{ deg.} = 942 \times 0.799 = 752$$

and

$$AN = AM \times \cos 8 \text{ deg.} = 752 \times 0.99 = 745$$

Therefore, the velocity of the crosshead at the given instant is 745 ft. per min.

This problem is inserted to illustrate the fact that it is possible for a single velocity to have a number of components acting in any number of directions. As a general rule the velocity of the crosshead will be determined graphically as shown in Fig. 62 instead of being figured numerically as has been done in this problem.

72. The resultant of the velocity with which the man is rowing the boat and the velocity of the stream must be a horizontal velocity if the boat is to land at a point directly opposite its starting point. In Fig. 63, let OA represent this resultant velocity, OB the direction the man has to head the boat and OC the direction of the current of the stream. From the conditions of the problem, OB equals six miles per hour and OC equals two miles per hour; hence

$$\sin x = \frac{AB}{OB} = \tfrac{2}{6} = 0.333, \text{ or } x = 19\tfrac{1}{2} \text{ deg.}$$

73. The velocity with which he is crossing the stream is given by the line OA (Fig. 63) which is equal to

$$OB \times \cos x = 6 \times 0.943 = 5.66 \text{ miles per hour} = 498 \text{ ft. per min.}$$

74. Time equals space divided by the average velocity.

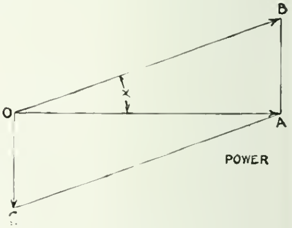


Fig. 63.

Or

$$time = \frac{1000}{496} = 2 \text{ min. (approx.)}$$

75. The desired velocity may be found by substituting the given velocities in equation (29). Thus V_1 = 50 ft. per min., V_2 = 75 ft. per min. and V_3 = 200 ft. per min. Hence, letting X equal the velocity of the load relative to the ground, there results,

$$X = \sqrt{50^2 + 75^2 + 200^2} = \sqrt{48,125} = 219+ \text{ ft. per min.}$$

Uniform and Accelerated Motion

Acceleration is the rate at which the velocity of a body changes and is expressed in the number of feet per second the velocity changes for every second the body is in motion. This acceleration may be *uniform* or *variable;* if uniform the velocity will increase at a uniform rate. *The formulas which are derived in this lesson apply only to problems involving uniformly accelerated motion.*

A body starting from rest and moving with an acceleration of a ft. per sec., at the end of T sec. will have acquired a velocity of aT ft. per sec. Let V = this velocity. Then

$$V = a \times T \qquad (30)$$

The average velocity during the time the body is in motion will be the sum of the final and initial velocities divided by two or

$$\left(\frac{0 + V}{2}\right) = \left(\frac{0 + aT}{2}\right) = \frac{aT}{2}$$

The space S passed over by the body will equal the average velocity multiplied by the time, or

$$\frac{aT}{2} \times T = \tfrac{1}{2} aT^2$$

hence,

$$S = \tfrac{1}{2} aT^2 \qquad (31)$$

Also, from equation (30),

$$T = \frac{V}{a}$$

Substituting this value for T in equation (31), thus

$$S = \tfrac{1}{2} a \times \left(\frac{V}{a}\right)^2 = \frac{V^2}{2a}$$

or

$$V^2 = 2aS \qquad (32)$$

and

$$a = \frac{V^2}{2S} \qquad (33)$$

Therefore, when a body starts from rest the acceleration may be found if the final velocity and the space passed over are known. Equation (33), it will be noted, is *independent of the time.*

Illustration: A train starts from rest and after it has passed over a distance of 1000 ft. attains a speed of 22 ft. per sec. What is its acceleration?

From equation (33) $a = \frac{V^2}{2S}$ where V = the final velocity in feet per second, and S is the distance passed over during the attaining of the given velocity,

$$a = \frac{22 \times 22}{2 \times 1000} = 0.24 \textit{ ft. per sec. per sec.}$$

In certain problems it may be desirable to express the acceleration in some other units as miles per hour per second, or miles per hour per hour.

If the body has an initial velocity of U feet per second before the increase in velocity takes place the formulas just stated will be somewhat modified. Thus, let U = the initial velocity of the body in feet per second. Then if the body moved with a uniform velocity only, for T sec. the space passed over would be UT ft. Now, if *in addition to the uniform velocity* the speed is being accelerated, then the space passed over during the time of the acceleration will be $\frac{1}{2} aT^2$, as shown in equation (31), to which must be added the space passed over due to the uniform velocity of U ft. per sec. Therefore, the total space passed over by a body moving with an initial velocity of U ft. per sec. which is accelerated at the rate of a ft. per sec. for a period of T sec., will be given by the equation,

$$S = UT + \tfrac{1}{2} aT^2 \qquad (34)$$

The final velocity of the body at the end of the period of acceleration will equal the sum of the initial velocity U, plus the gain in velocity, which, from equation (30), is aT. Let V_1 = the final velocity, then,

$$V_1 = U + aT \qquad (35)$$

Example: A train is running at 15 miles per hour (22 ft. per sec.). The engineer turns on more steam so as to give an acceleration of 0.75 ft. per sec. per sec. (*a*) What is the velocity of the train at the end of 8 sec.?

From equation (35), $V_1 = U + aT$, where $U = 22$ ft. per sec., $a = 0.75$ ft. per sec. and $T = 8$ sec.; hence,

$$V_1 = 22 + 0.75 \times 8 = 28 \textit{ ft. per sec.}$$

(*b*). How far did the train move while the gain in speed took place? From equation (34), $S = UT + \frac{1}{2} aT^2$ where $U = 22$ ft. per sec., $T = 8$ sec. and $a = 0.75$ ft. per sec.; hence,

$$S = 22 \times 8 + \tfrac{1}{2} \times 0.75 \times 8^2 = 200 \textit{ ft.}$$

The average velocity during the time the body is in motion is $\frac{U + V_1}{2}$ and the space passed over in T sec. is S, whose value is

$$S = \left(\frac{U + V_1}{2}\right) \times T \qquad (36)$$

From equation (35), $T = \left(\frac{V_1 - U}{a}\right)$. Substitute this value of T in equation (36) and there results,

$$S = \frac{(U + V_1)}{2} \times \frac{(V_1 - U)}{a} = \frac{V_1^2 - U^2}{2a}$$

or

$$V_1^2 - U^2 = 2aS \qquad (37)$$

Equation (37) may be used to check the results of the above problem, thus the final velocity V_1 of the train was found to be 28 ft. per sec. and the initial velocity was 22 ft. per sec. and the acceleration 0.75 ft. per sec. Substitute these values in equation (37) and there results,

$$28^2 - 22^2 = 2 \times 0.75 \times S$$

or

$$S = \frac{28^2 - 22^2}{2 \times 0.75} = \frac{784 - 484}{1.5} = \frac{300}{1.5} = 200 \textit{ ft.}$$

If the velocity of a body is being decreased there will take place a deceleration or retardation in place of an acceleration and the value of a will become *negative* instead of *positive.* The formulas for retarded motion will be as follows:

$$S = UT - \tfrac{1}{2} aT^2 \qquad (38)$$

$$V_1 = U - aT \qquad (39)$$

$$V_1^2 = U^2 - 2aS \qquad (40)$$

Study Questions

76. A subway train starting from rest attains a speed of 30 miles per hour (44 ft. per sec) in a distance of 800 ft. What is the acceleration in feet per second per second?

77. The velocity of a moving body changes from 66 to 22 ft. per sec. while the body moves through a distance of 1000 ft., what is the retardation?

78. Express an acceleration of 2 ft. per sec. per sec. in miles per hour per second; in miles per hour per hour.

79. A train is traveling at 60 miles per hour (88 ft. per sec.). The engineer applies the brakes and at the end of 20 sec. the speed is reduced to 15 miles per hour (22 ft. per sec.). Find the deceleration.

80. How far did the train travel during the application of the brakes?

⁂

Efficiency Experts Take Notice—From figures quoted in the "Electrical World" it appears that London's electrical supply is furnished by no less than 65 separate installations, both private and municipal. These comprise 31 different systems of generation, 21 distributing voltages, eight different frequencies, and, to make the situation more confusing, there are 50 methods of charging for the output.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

THE ENGINEER

(As seen by the office boy)

By R. T. STROHM

The engineer? Oh, he's the gink
They cuss when lights go on the blink.
You'd think that any fool would know
Enough to make an engine go.
Sometimes I'm sure it balks and stalls
Because it hates his overalls—
You know, the blue kind worn by rubes
And harvest hands and other boobs.

The engineer? Oh, he's the dub
That every morning has to scrub
The tarnish off the copper signs
And polish each until it shines.
And maybe once or twice a week
They call him in to fix a leak.
But say! I'd know what loafing is
If I'd a lead-pipe cinch like his!

The engineer? Oh, he's the bo
That keeps the sidewalk clear of snow,
And fixes locks, and glazes doors,
And varnishes the office floors.
His work's not half as hard to do
As that which falls to me or you;
Yet yesterday he had the cheek
To ask for sixteen bones a week.

The engineer? Oh, he's the chap,
With grease and coal-dust on his map,
Who spends his time in cutting rings
To put in pipes and pumps and things.
Sometimes he carts a load of coal
And heaves it through the fire-hole;
But say! if I'd a snap like that,
The rest I'd get would make me fat!

⁂

You'd never believe that tempus fugits if you could have glimpsed the Stevens Institute 100 per cent. bunch the other night. No Geyer crowd of Coster mongers ever get together than old '77 at its annual fiesta. Pearce and Roberts made home runs by proxy. And on the brink stood Brinckerhoff! John Rapelje is the only boy whose headpiece needs no mortarboard to save his scalp from sunburn, and it takes Idell to bring up the Van. As usual, Nash metered out the water at the Engineers Club, and Uehling got a CO_2 record of the cider. Whurroo! Vive! and Gesundheit ad libitum!

⁂

Charles O. Sandstrom, Kansas City, Mo., wins the prize in the Why-I-Work-in-a-Power-Plant contest. Clifford Danner, Lacombe, Alta., Canada, has honorable mention.

Mr. Sandstrom's answer is as follows:

Editor of the Spillway:

"Why do I work in a Power Plant?" Well, I might say, "Because I love Horticulture," but I won't. It is because—

I love the beteunits, that scamper through the main; and the amperevolts so frisky, though they sometimes give me pain: but I do detest a high C. oh! no matter how 'tis had; while I can stand just one low C, oh! two is very bad. I love the lushuscurrents, from the dinamosogrand; and the cleverlittlentropy does surely beat the band: but I do dislike a blounoutube, no matter how 'tis got; and a pesky, leekeeblowoff would make me kill a watt.

And here is Mr. Danner's reply:

Editor of the Spillway: I work in a power plant because the work appeals to me. It affords an outlet for my natural abilities, and thus makes life better. It is an honest and upright work, and while affording me congenial work, I am enabled to do others a good service. And it is the means whereby I can make a good living.

The replies came from Canada and Texas, from California and along the coast—from every state. We are proud of these letters, their humor, their optimism and, above all, their evident pride and high respect for the vocation of the operating engineer. Now and again, we have tried to inject a serious thought in this column—and this time we surely hit the mark. It's fine!

N. A. S. E. Milwaukee Program

From all indications, the thirty-second annual convention of the National Association of Stationary Engineers, to be held in Milwaukee, Sept. 7 to 12, will be a decided success. Headquarters will be at the Hotel Wisconsin. The convention will be held in the Auditorium, with its seven halls and unsurpassed facilities for large gatherings. The business sessions and the exhibit will therefore be under one roof, and the location is central to the business and hotel district.

Milwaukee is an ideal convention city. Its parks and summer resorts are numerous and its varied manufacture of power-plant equipment and supplies should prove of no little interest. The following program is an outline of what the local committee has prepared for the great annual event:

MONDAY, SEPT. 7

9 a.m. to 9 p.m.—Reception of delegates and visitors at the trains; escorted to the hotel by the band. Registration of delegates and visitors and distribution of badges at Auditorium.

8 p.m.—Official opening of exhibits in the exposition hall, John A. Wickert, chairman of the local convention committee, presiding. An address by Homer Whelpley, president of the National Exhibitors Association. Response by the national vice-president, Frederic L. Ray. Official opening by James R. Coe, national president.

TUESDAY, SEPT. 8

10 a.m.—Opening exercises at the convention hall, John A. Wickert, chairman of the local convention committee, presiding.

Invocation, Rev. W. T. Dorward.

Address, Welcome to Wisconsin, by Hon. F. E. McGovern, governor.

Response by National President James R. Coe.

Address, Welcome to Milwaukee, by Hon. Gerhard Bading, mayor.

Response by National Vice-President Frederic L. Ray.

Address by J. P. Keenan, secretary of the Citizens Business League.

Response by Past-President John F. McGrath.

Opening of the convention by National President James R. Coe.

Appointment of convention committee.

Official photograph immediately after adjournment. Recess.

2 p.m.—Session of the convention in Juneau Hall, Auditorium, where all sessions of the convention will be held. The usual order of business will be followed, including reports from the various officers and committees and a meeting of the life and accident department.

LADIES' AUXILIARY

The opening exercises of the Ladies' National Auxiliary Convention will be held in the ball room, second floor of the Hotel Wisconsin; Mrs. Rose J. Tellier, chairlady of the Ladies' Auxiliary Committee, presiding.

Invocation by Rev. W. T. Dorward.

Address, Welcome to Milwaukee, by Hon. Gerhard Bading, mayor.

Response by Ollie L. Heckler, past president.

Opening of the Ladies National Auxiliary convention by the national president, Mrs. Sophie Whelan.

Appointment of convention committees. Tea and musical in reception room of Hotel Wisconsin.

3:30 p.m.—A trip to one of Milwaukee's famous institutions.

8:30 p.m.—Prize card party for the ladies in Kilbourn Hall, Auditorium.

10 p.m.—Smoker under the auspices of the exhibitors in Juneau Hall, Auditorium.

WEDNESDAY, SEPT. 9

9 a.m.—Session of convention.

9:30 a.m.—Session of ladies auxiliary convention in the ball room of the Hotel Wisconsin where all the sessions will be held.

12 noon—Street cars to the engine builders: luncheon at the Allis-Chalmers Co.'s works at noon.

8 p.m.—Band concert in the exhibition hall, Auditorium.

THURSDAY, SEPT. 10

9 a.m.—Session of the convention.

9:30 a.m.—Session of Ladies Auxiliary.

11:30 a.m.—Annual memorial service will be held (quartettes).

2 p.m.—Athletic events including annual baseball game between the engineers and the exhibitors.

9:30 a.m.—Session of the Ladies Auxiliary.

Ladies' day at the exposition hall; souvenirs given on this day only.

8:30 p.m.—Vaudeville show by exhibitors in Plankinton Hall, Auditorium.

FRIDAY, SEPT. 11

9 a.m.—Session of the convention. Reports of the convention committees; discussion and action on same; unfinished business; selection of 1915 convention city; election of officers.

9:30 a.m.—Session of Ladies Auxiliary.

8:30 p.m.—Installation of officers and presentations. Grand ball and cotillion conducted by H. T. McConnell, at Engleman's Hall, Auditorium.

SATURDAY, SEPT. 12

Delegates and visitors will be escorted to places of interest.

On Sept. 6 and 7 the Wisconsin State convention will be held, the opening exercises taking place on Sunday and on Monday the business sessions.

Heavy Oil Engines in Small Units

At the annual convention of the National Gas Engine Association in Chicago on June 25, H. F. Shepherd, engineer of the Bessemer Gas Engine Co., read a paper on the small oil engine. His remarks in abstract appear in the following:

It is reasonable to expect that the history of the small oil engine will parallel that of the small steam and gas engine. The late Dr. Diesel taught how to build the most efficient prime mover from thermal considerations, and his work for the building of large engines has met world-wide appreciation. The mechanism of these engines, although it may be sturdy as built for heavy units, becomes delicate when an attempt is made to design small sizes, and it will be understood that, notwithstanding the good returns from recent land and marine installations, the type does not accord with the adverse conditions of intermittent and unskilled care and improvised erection under which small units must operate.

Careful study of tendencies both here and abroad seems to indicate that the future small oil engine, up to 100 hp., will be of the hot-bulb type, and judging from the many designs emanating from old and established forms, the two-stroke-cycle hot-bulb engine is receiving special favor. Although this motor is distinctly an American product and no longer novel here, Denmark and Sweden have done some wonderful work along these lines in the past three years. In Denmark, especially, where engine builders have entered their products for test at various trials during this period, the two-stroke-cycle models have been steadily gaining points and the number of entries of four-stroke-cycle hot-bulb engines has diminished.

Building oil engines has been of necessity an extensive business in England for many years, most of the models produced having been of the four-stroke-cycle, low-compression type, using internal or external vaporizers. The attitude of the English technical press toward the newcomer during 1912 displayed doubt in spite of growing production, and builders were censured for so called extravagant claims, but interest was shown and many new designs were described. Not until 1913 did this engine really come into its own in that country as a prime mover of real technical interest, for in that year competitive trials on the Continent were published widely and many engineers representing the owners of these engines came forward to champion the cause. Most interesting was the editorial in "Internal Combustion Engineering" (London) at the close of the year, reading in part as follows:

> It can be asserted without fear of contradiction that the greatest feature of internal-combustion engineering during 1913 was the wide extension of patronage accorded to the hot-bulb engine. Not only have many new manufacturers been convinced of the merits and advantages of this type of motor, but there has been a world-wide demand for it. The reasons for this great and growing popularity are not difficult to see Primarily, this type scores by its economy, but of far greater benefit is its reliability with many different sorts of fuels. Although it is now being manufactured with an output extending to nearly 100 hp. per cylinder, its greatest application is found in moderate powers where it is rapidly replacing the older form of paraffin engine, which at one time held the market to itself. It is inevitable that not every example of the type should attain the high level of excellence which has been set by leading productions and regret must be expressed that certain manufacturers have obtained neither reliable nor economical results.

It would seem that the features of the two-stroke cycle construction upon which critics have spoken tend to improve the combustion of the injection type of hot-bulb engine It is often stated that, due to the alleged low volumetric efficiency of the charging arrangements of engines not employing scavenging pumps of greater displacement than the cylinders, imperfect combustion will result due to imperfect scavenging. In the light of present-day knowledge, it is known that, within certain limits, the presence of neutral gases results only in the necessity of designing for somewhat lower mean effective pressure, and while a reduction of mean effective pressure would have some disadvantage for four-stroke-cycle construction, it does not put the two-stroke-cycle motor out of the running for the reason that every revolution gives a power stroke per cylinder and the motor can still be kept well within the usual weight limits. The mean effective pressure upon which these engines are usually rated is not the maximum possible, but that at which the greatest economy of fuel is attained. A well designed engine like the Diesel will carry overloads up to 50 per cent., although the combustion, due to the small excess of air present, will not be all that would be desired.

The admixture of the fresh charge with the high-temperature neutrals left behind, together with the heat absorbed during the scavenging process, will result in an initial temperature before compression considerably higher than the atmospheric temperature. In view of this, data can be offered which would go to prove the temperature, before the explosion at full load, to be never less than 850 deg. F., with but 180 lb. compression resulting in a high final temperature, approximating Diesel temperatures after combustion and a consequent good consumption of residues. To reduce the necessary compression it has been proposed repeatedly to preheat the air charge of the four-stroke-cycle Diesel engine. Naturally, the proposal has not found favor because of the increased cylinder size necessitated.

The practice of feeding water with the air charge has been criticized as resulting in a large thermal loss due to the latent heat of the water lost in the exhaust. Still, it is known that, because of some chemical or physical action, as yet under debate, the water feed results in better combustion. There is ample proof that, with a proper rate of feed, the water is completely vaporized by contact with the piston, cylinder walls and exhaust gases before the beginning of the compression stroke, and is carried as superheated steam through the cycle. What effect is exercised over temperatures occurs through a change in the initial temperature before compression only. The latent heat lost is that which would be lost to the jackets and exhaust normally, the actual jacket loss, when internal water injection is employed, falling as low as 3½ per cent. and seldom exceeding 10 per cent. in comparison with the usual jacket loss of other types, which varies from 20 to 30 per cent. Mechanically, the extraction of the heat directly from the piston itself and from the interior of the cylinder walls has greater advantages in the way of permitting good lubrication and of reducing expansion stresses in the castings.

As to the fuel range of these engines, it might be said that short of California and Mexican crudes or residuals testing high in coke, it embraces practically all petroleum fuels offered for engine use that are heavier than the naphthas, such as many crudes, residuals and fuel oils, all gas oils, distillates and kerosenes. Further, it is found that the base of the fuel is not of the least importance, there being no tendency to form carbon as long as the coke residue is within the 4 per cent. limit usually prescribed for Diesel-engine fuels. If the engine is given the necessary attention, fuels showing coke up to 9 per cent. may be used with good results.

The full load fuel economy will vary with the size, running from 0.6 lb. per brake-horsepower-hour for large engines, to 0.85 lb. for the smaller sizes. The economy varies but little for a wide range of fuels and is approximately the same from three-fourths to full load, and less than 15 per cent more fuel per unit is required at half load.

For driving generators the speed possibilities of the two-stroke cycle, high-compression type of engine are favorable. Because there is compression at every revolution to cushion the parts over the in-center, any lost motion in the bearings is harmless as the reciprocating parts never leave their journals, there being no reversal of pressure and no stress on the connecting-rod bolts.

Considerable criticism has been directed against the two-stroke-cycle engine as crank-case compression has caused various ills, but by the use of a crosshead and a closed cylinder end, such troubles are avoided and the life of the engine increased.

To Fight Municipal Utility Corporations

A coalition of the cities of the country, big and little, has been formed to fight the combination of municipal utility corporations, big and little, that has for a generation operated to thwart municipal progress and growth.

Leading the movement are the mayors of Philadelphia, Chicago and New York. The mayors of these three largest American cities are interested in seeing that rates and service for public utilities shall hereafter be based on the actual value used and useful for such purposes, and not on the power of a monopoly to extort what rates it will; and not on a capitalization that represents merely the selling power of utility promoters. The organization has already been started and a conference called to discuss the vital factors in these problems.

PERSONALS

J. C. Stout has recently succeeded J. M. Chapman as manager of the Cleveland, Ohio, office of the Crandall Packing Co.

Dudley A. Johnson has succeeded the late Sam Mayer as Chicago branch manager of the Joseph Dixon Crucible Co. He was formerly Mr. Mayer's assistant in that office.

Edward Holden, for a number of years connected with the heating and ventilating firm of Evans, Almirall & Co., New York City, has resigned his position.

Harry F. Bower, vacuum-heating expert with Warren Webster & Co., Camden, N. J., for twenty-three years, has resigned his position as manager of that company's Boston office.

G. A. Reichard, of the Los Angeles office of the International Steam Pump Co. will sail from San Francisco, July 11, on the Pacific Mail Steamship "Manchuria" on a four months' business trip to Japan, China and the Philippines.

Harry J. Marks, manager of the New York office of the American Engine & Electric Co., has been advanced to the position of sales manager of the company. He will divide his time between the New York office, 90 West St., and the main office of the company, at Bound Brook, N. J.

John H. Adams has been appointed engineer in the power department of the West Penn Traction Co., Pittsburgh, Penn. He began work at 16 in the motor-winding department of the Augusta (Ga.) Ry., and worked through the car shops, power stations, overhead-line department, maintenance-of-way department, etc. He was made chief engineer and assistant to the general manager at the time the late Edward H. Harriman purchased the property at Augusta in 1908 and continued in this capacity until J. G. White & Co., New York, took over the operation, when he was made engineer of maintenance-of-way and superintendent of motive power. Mr. Adams resigned from this last position to become connected with the West Penn Traction Co.

OBITUARY

HARRY F. FEY

On June 2 Harry J. Fey was taken suddenly ill, and died in the Johns Hopkins Hospital, at Baltimore, Md., on June 6. For the past three years Mr. Fey was in the employ of the Dearborn Chemical Co. He had a wide circle of friends and business acquaintances who will sincerely regret his sudden death.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Bates Mfg. Co., Lewiston, Maine, is building a new boiler house, 59x165 ft. New equipment will be needed.

A power plant, according to press reports, will be built on Deer Island, Boston, Mass., to furnish power to operate the plants on the island.

SOUTHERN STATES

On June 16, fire destroyed the South Boston Electric Light & Power Plant, South Boston, Va.

The Hamblen County Creamery Co., Morristown, Tenn., will erect a plant. Power equipment and refrigerating machinery will be needed. W. H. Mullins is Pres.

The Butler Creamery Co., Butler, Ky., is in the market for refrigerating equipment.

The S. F. McCormick Lumber Co., Lexington, Ky., will soon be in the market for motors for a new planing mill which it will erect.

CENTRAL STATES

Bonds for $120,000 have been voted for the construction of a municipal electric-light plant at Norwalk, Ohio.

The Springfield Street Ry. Co., Springfield, Ohio, will erect a new power plant. Power-plant equipment will be required.

Bids will be received until July 14 by the City Clerk, Tell City, Ind., for furnishing new power plant-equipment for the water-works. Robert M. Cass, 318 American Life Bldg., Indianapolis, is Consult. Engr.

WEST OF THE MISSISSIPPI

W. J. Squires, Leavenworth, Kan., contemplates constructing an electric-light plant at Leavenworth.

At a recent election, Powhattan, Kan., a bond issue of $10,000 for the construction of a municipal electric-light plant was voted.

Bids will be received by the city of Alexandria, S. D., about Aug. 1, for the construction of a municipal electric-light plant. H. M. Schumacher is city auditor.

Plans are being prepared by the De Leon-Gorman Light & Power Co., Gorman, Tex., for the construction of a power plant at Gorman.

The municipal electric-light plant, Taft, Tex., which was recently destroyed by fire, will be rebuilt.

The Sugar Pine Box Co., Riddle, Ore., plans to install an electric-light plant. Equipment will be needed. W. W. Vaughn, Riddle, is the Engr.-in-Charge.

F. D. Small and D. C. Urie, Tillamook, Ore., have been granted a franchise to construct and operate an electric-light plant at Tillamook. The estimated cost is $30,000.

The substation of the Pacific Gas & Electric Co., Oroville, Calif., was completely destroyed by fire June 19. Loss, $10 000.

The Central California Gas Co. will construct a purifier, boiler and compressor at Visalia, Calif., and will also make additions and other improvements to its plant.

CANADA

The city of Montreal, Que., will construct a municipal electric-light plant costing $172,667.

BUSINESS ITEMS

The Mesta Machine Co., Pittsburgh, Penn., has issued a new bulletin on Air Compressors and Vacuum Pumps—Bulletin N. It goes into complete details, contains a number of illustrations and should be of interest to every engineer. Copies are sent on request.

The Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo., has just closed a contract with the Lake Torpedo Boat Co. for six 600-b.hp. reversible two-cycle marine Diesel engines, whic hare to be installed on three twin-screw submarine torpedo boats now building for the U. S. Government.

The Nordberg Mfg. Co., Milwaukee, Wis., is now building Diesel engines, particularly of the largest sizes, having recently entered into an exclusive manufacturing arrangement with Usines Carels Freres, of Belgium, builders of the celebrated Carels engines.

An interesting book just published by the Smooth-On Manufacturing Co., Jersey City, N. J., is the new Smooth-On Instruction Book No. 7, devoted exclusively to the use of Smooth-On Iron Cement No. 7 for hardening, waterproofing, and oil proofing concrete. Copies will be mailed free on request.

TRADE CATALOGS

A. D. Granger Co., 90 West St., New York. Bulletin No. 2. "Oswego" internally fired water-tube boilers. Illustrated, 12 pp., 8x10 in.

Joseph T. Ryerson & Son, Chicago, Ill. Technical Library No. 4. Internal furnace boilers with Morison corrugated furnaces. Illustrated, 84 pp., 4½x7 in.

The Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog S. Brownhoist suspended concrete bins. Illustrated, 40 pp., 6x9 in.

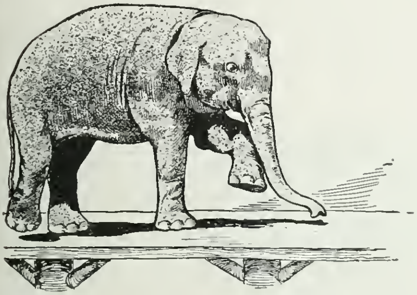
American Steam Gauge & Valve Mfg. Co., 208 Camden St., Boston, Mass. Catalog. "Thermofeed" regulator or controller. Illustrated, 40 pp., 5½x8½ in.

Chain Belt Co., Milwaukee, Wis. Catalog No. 54. "Chabelco" steel chain belt. Illustrated, 32 pp., 7x10 in.

Armstrong Cork & Insulation Co., Pittsburgh, Penn. Catalog. Nonpareil cork covering for cold pipes. Illustrated, 64 pp., 6x9 in.

POWER

Vol. 40 NEW YORK, JULY 21, 1914 No. 3



Candid Chats

Be Sure of Your Ground

Let us have a heart to heart talk on the central-station-isolated-plant situation

You have seen a circus elephant, crossing a small bridge, test it at every step to make sure that it would sustain his weight. He knows he must be "sure of his ground," for with his great weight a fall is serious. Not so with the lizard. Put him on a table and he will walk blindly off and fall. Having less need of it he has developed no sense of caution.

This central-station-isolated-plant discussion that is so absorbing has on each side of it men who represent the elephant and those who are comparable with the lizard, however good the intentions of the latter. Those with a reputation to sustain are slow about passing opinions. The others either have no reputation or anything else at stake, or they are very careless.

Institutions do not thrive and grow in a community when there is no demand for them. When there is need for any industry it develops until that need is fulfilled and ceases to develop further unless the demand is forced and stimulated by artificial means. It is when these latter tactics are employed that there is a clash of interests in the community. Those who so promote a project, find themselves opposed by those whose interest they have jeopardized. But both sides should recognize that each has a field which it alone can best serve. Each is useful if rightly used. The public knows this and laws and commissions are provided to direct the business of each to this end.

The foregoing expresses the central-station-isolated plant situation.

The engineer must concede that the central station as well as the isolated plant has its field of usefulness. There are places where central-station service is warranted and advisable beyond question. There are others where central service has no possible advantage. These extremes are not debatable, but there are places where it could not be accurately determined without thorough investigation, which kind of service is best. One cannot walk into such a plant and give a snap decision that is worth consideration. Then is the time to emulate the elephant.

As an example of a place of the first kind, take a warehouse where the lighting load is small and uniform, but the elevator load is heavy and widely fluctuating. The plant must be large enough to carry the maximum load and be ready to carry it at all times. These are uneconomical conditions for the isolated plant, and central-station service should prove advantageous if the rate is fair. Salt works, bleacheries, thread and cotton mills, dye houses, etc., are examples of the second kind. The load is fairly constant and there is use for all exhaust steam; mixed-pressure turbines may be installed to advantage. Hotels need exhaust steam for heating in winter and for absorption refrigeration plants in summer.

The plants of the middle class are far more numerous than the others. They are the storm centers. They must be operated skillfully; the engineer must realize that his work here is not a mere job. It is a many-angled business proposition. In selling power, as in selling anything else, advantage must be taken of every legitimate opportunity. The central station does this through trained experts in its various departments. These constitute the competing business forces arrayed against the engineer. This is the condition he must meet.

To meet it successfully he must know what is good practice, how to apply it to his particular plant and to tell how well he is applying it. All this requires more knowledge and more work than formerly. The engineer cannot better matters by vehement protests and wild assertions, but he can, by attacking the problem rightly – by being "sure of his ground," like the elephant. When individually, he feels the need of a consulting engineer he should see to it that he gets a good one.

The sources of helpful information are many. There are the power-plant papers, cheap but good bound books, engineers' organizations, with their lectures and general educational work (altogether too much neglected by the rank and file), public libraries, schools, many of them free, and, lastly, the plants of engineer friends.

It is told that King Alexander, when a student, asked his instructor if there was no short cut to algebra. The good instructor replied that there was no royal road to mathematics. There isn't. It's hard plugging. And so it is with good power-plant engineering.

Producer Gas for Industrial and Power Purposes

By Thomas Wilson

SYNOPSIS—This is a producer plant, with special control features, which supplies gas under suction and under pressure for power and industrial purposes.

⁂

Within the last few years the use of gas for heating purposes in many industries has greatly increased. Cleanliness and convenience and the ease with which it can be controlled so that the temperature can be closely regulated have been the deciding factors. Natural and city gas have been used to good advantage, but for low-temperature work up to 2000 deg. F. anthracite producer gas has given equal satisfaction at a much lower cost. The cost item has induced manufacturers to install gas producers using inferior grades of anthracite to supply gas, not only for heating purposes, but for power.

A plant involving this double service has been installed in the new factory of Barnhart Brothers & Spindler, Chicago, makers of type and printers' supplies. The new building, measuring in plan 200x236 ft., has two stories and a basement and over 100,000 sq.ft. of floor space. The gas is used for melting the metal in type-casting machines, for hardening furnaces, machine torches, brazing torches, for lead and slug casting, in annealers, copper- and nickel-plating baths, etc. About 70 per cent. is required for these purposes and the balance by the engine units generating current for power and lighting.

There are 70 type-casting machines, each equipped with individual motors. All chases are electrically welded, for which fully 75 hp. is required. A machine shop in which the factory machines are made and repaired takes considerable power; besides, there are electrically driven pumps and fans, and an elevator and conveying machinery to move the product in the course of manufacture. When the plant is running to full capacity, with the chase department in operation, the load will average close to 150 kw., and when chases are not being welded it will drop off one-third. Consequently, two units have been installed, one a 125-hp., 17¼x16-in., four-stroke-cycle tandem gas engine directly connected to a 75-kw. direct-current generator, and the other a twin engine of the same type and size of cylinders driving a 150-kw. generator; the speed in each case is 250 r.p.m. These machines are operated 10 hr. a day, and it is the plan to use them alternately, depending on the welding periods. The plant also has a breakdown service, but so far it has been called on only for night lighting, for the fire pumps and for starting the blower run in connection with the two producers of 350 hp. each.

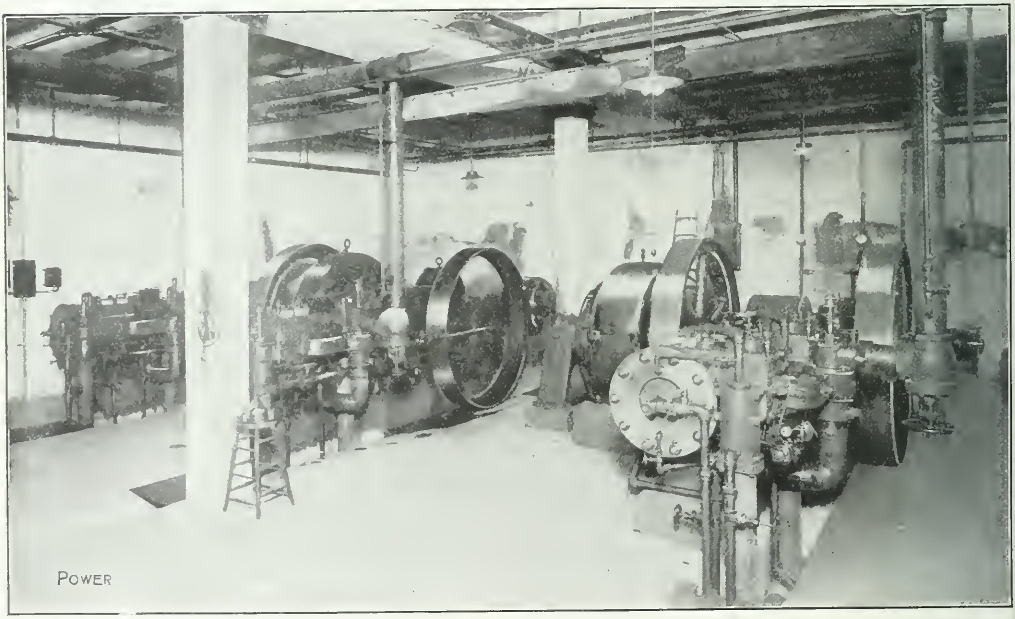


Fig. 1. Gas-Engine Plant at Barnhart Brothers & Spindler

As the plant has been running only a short time no satisfactory records are available, but it may be said that the gas, which averages about 145 and has reached 151 B.t.u. per cubic foot, has given excellent satisfaction both for heating and power purposes. About 95 lb. of buckwheat No. 1 in the producer is equivalent to 1000 cu.ft. of natural gas containing 800 B.t.u. per cubic foot, and 75 lb. is equivalent to the same quantity of city gas containing 550 to 600 B.t.u. At $5 per ton, which is a high charge for such coal in quantities, the fuel cost would be 24 and 19 cents, respectively. To this must be added the labor item and the interest and depreciation on the producer installation; even then the total cost does not exceed much more than one-third the usual charge for city gas. In a preliminary estimate, the equivalent of 1000 cu.ft. of city gas was figured to cost 31.3c., including a charge for water and interest and depreciation amounting to 16 per cent. For the engines the guarantee was 1⅛ lb. of buckwheat No. 1 per brake horsepower-hour at full load, which at $5 per ton gives a fuel charge of 0.28c. This amount will generate about 79 cu.ft. of producer gas, and with a heat content of 145 B.t.u. will supply 11,455 B.t.u. per boiler horsepower-hour

THE PRODUCER PLANT

In this department each of the two Flinn & Dreffein units is rated at 350 hp. and consists of a producer and an economizer; a scrubber serves the two generators. The producers, of the water-sealed type, have a heavy steel shell 8 ft. in diameter by 12 ft. high, firebrick lined, and rest on legs in a concrete pan. The fuel is supported on a layer of ashes on the bottom of the pan. Between the bottoms of the shell and the pan there is a clearance of 12 in., and as the pan diameter is greater than that of the shell, there is room for removing the ashes, which are placed in 400-lb. cans, hoisted to the street level and carted away.

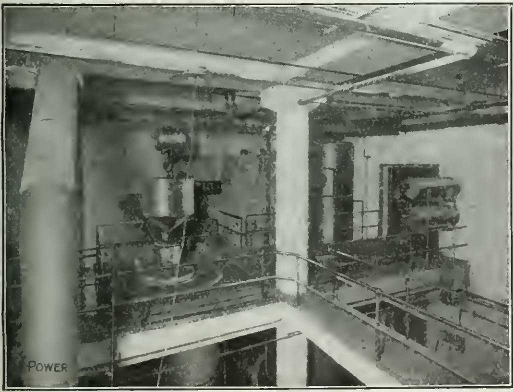


FIG. 2. CHARGING FLOOR OF PRODUCERS

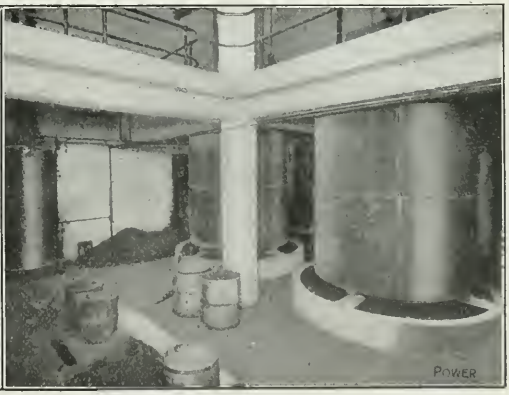


FIG. 3. BOTTOM OF GENERATORS AND STEAM BOILER

Coal from a 100-ton bunker below the street level is delivered by gravity through a chute into the bucket of a one-ton electric monorail hoist, which for feeding can be moved directly over the hopper of each producer. At their rated load the two require 750 lb. of coal per hour, although they are now running at only two-thirds capacity. The producers are not charged heavily, but are fed uniformly with 150-lb. charges at 35-min. intervals. The hoist bucket easily holds ten charges, and is usually filled four times each day.

The coal enters the producer through a double-seal hopper, a counterweighted bell at the bottom of the hopper preventing the admission of air while the coal is being fed. The sliding plate at the top is closed while the bell is lowered, so that the coal may run down over it and be evenly distributed over the fuel bed. The hopper rests on a water-cooled top having poke holes for attending to the fuel bed.

A feature of the producer is the annular tuyere of dog-house cross-section, which uniformly distributes the air and steam to the fuel bed. This construction facilitates the ash removal, as the ashes can drop around or within the annulus and easily reach the concrete pan at the bottom.

An important part of the plant is the economizer, which in the present installation is 9 ft. high and 42 in. diameter, and consists of two concentric steel shells forming two chambers. The gas from the generator passes through the inner one and gives up part of its heat to the air flowing in the opposite direction through the outer chamber to the fuel bed. Ordinarily the gas leaves the producer at 1200 deg. F., and if it passed directly to the scrubber it would carry about 12 per cent. of the heat in the coal. By raising the temperature of the air to 500 deg. in the economizer two-thirds of this heat is reclaimed.

In the pipe connection between the top of the outer chamber and the tuyere of the producer, a steam blower is inserted to saturate the air and equalize the pressure in the top of the producer; otherwise, there would be a slight depression caused by the suction of the engines and of the blower supplying the shop equipment. Atmospheric pressure is thus maintained so that there is no tendency for air to be drawn in or gas to be blown out through the poke-holes when attending the fuel bed.

With the air at this high temperature, combustion is facilitated and the steam is carried to the fuel bed without condensation; it is also claimed that a richer gas is thereby obtained. The steam is supplied by a small vertical fire-tube boiler rated at 15 hp. and having a pressure of 50 to 80 lb., depending on the load the producers are carrying. The quantity of steam is controlled by a gasometer connected by block-and-tackle to a weighted lever attached to the stem of the balanced steam valve. The gasometer connects with the top of the producer. As the load increases, the gas pressure tends to drop, so that the gasometer lowers slightly, and, through the connecting links, increases the opening of the steam valve. A drop in load produces the reverse results.

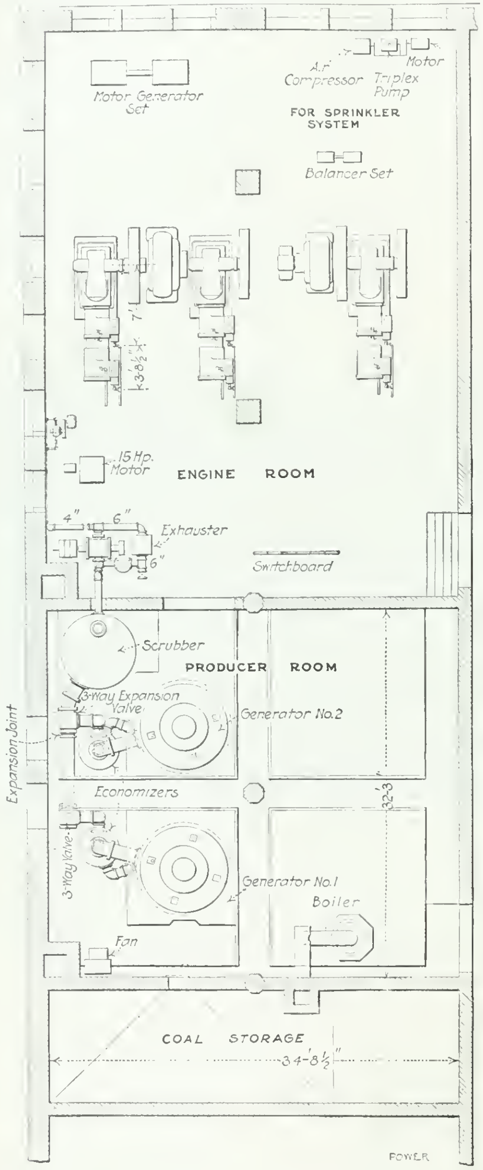


Fig. 4. Plan View of Engine and Producer Rooms

From the economizer to the wet scrubber the gas passes through a three-way water-sealed valve from the top of which the purge pipe leads to the roof. Water sealing the valve eliminates any possible trouble from tar and soot sticking to a dry seat and makes the tightness of the valve more certain. The scrubber serving the two units is 6 ft. 6 in. in diameter by 22 ft. high, and contains a coke column supported on trays, water sprinklers above, and at the top a layer of excelsior to remove the moisture.

From the scrubber the gas is drawn directly to the engines by the suction of the pistons. As for industrial purposes, it is necessary to supply the gas at a definite and uniform pressure; there is an exhauster belt driven by a 15-hp. motor. Instead of using a gas holder, a pipe connection is made between the delivery and suction sides of the exhauster. In this line is a back-pressure valve weighted for the desired pressure; when this exceeds the predetermined value, the valve opens and returns part of the gas to the suction side of the exhauster. The latter is run at constant speed so that the maximum output will be available. To the valve spindle is attached a diaphragm subject to the pressure in the gas main, and opposing this are weights on the upper side of the diaphragm. The construction is such that the diaphragm casing may be rotated at will, pulling with it the valve disk and thus keeping it free from soot or deposit by the grinding action on the seat.

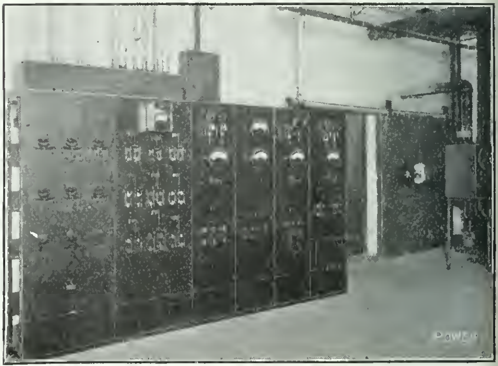


Fig. 5. Switchboard, Static Washer and Exhauster

For the engines, the gas is clean enough as it comes from the wet scrubber, but for small burner work it must also be passed through a static washer operating on the impact principle. The washer, Fig. 6, consists of a chamber having two compartments, the upper one giving space for gas admission and a spray of water. Hanging from the dividing wall is a threaded cylinder with a piston having threads of the same pitch, but not in contact with those of the cylinder wall. Both are so tapered that as the piston is moved downward the flow area is lessened and the velocity of the gas is increased, or *vice-versa*. The stem attached to the piston has threads of the same pitch also, so that in moving the piston up or down there is no variation in the "mesh."

In passing through this zigzag course, the remaining soot particles in the gas are deposited on the metal surfaces and washed down through the drain at the bottom of the lower compartment. The purified gas passes on to the burners.

Engine Room

The engines are of the tandem type directly connected to 110-, 220-volt, three-wire generators, with a balancer set. Rites inertia governors acting through balanced cutoff valves control the speed, and under the severe conditions imposed by the welding department they have maintained close regulation.

The plant is distinctive in design in that any part of either engine, with the exception of the crankshafts and flywheels, is interchangeable, and either half of the twin engine can be run independently of the other. In this way, one tandem unit can be out of service and the other two will be available to furnish the maximum load of 150 kw.

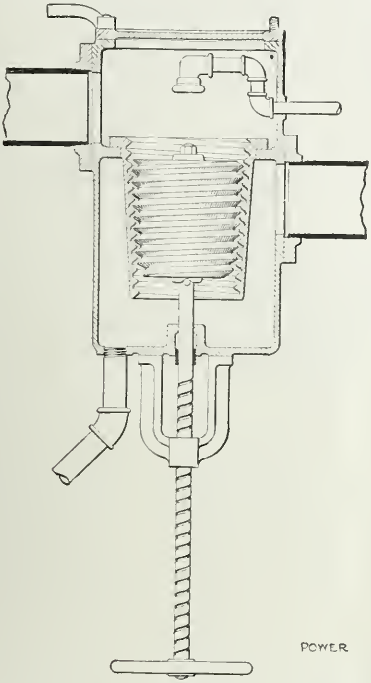


Fig. 6. Sectional View through Static Washer

A 10-in. pipe from the scrubber, with 6-in. taps to each tandem unit, supplies the gas to the engines. From the twin engine, two 6-in. exhaust pipes discharge to a 12-in. muffler; this reduces to 8 in. as it leads to the roof. The single tandem engine has a 6-in exhaust, a 10-in. muffler and a 6-in. riser.

Air for starting is stored in two 30-cu.ft. tanks at 200-lb. pressure during the day by a motor-driven compressor. From a 5000-gal. tank on the roof cooling water flows through the engine jackets and then to the suction of a 2-in. motor-driven centrifugal pump which returns it to the tank through a cooling tower above the tank. In case of accident to the pump, city water will be used temporarily.

Other equipment includes a pump and air-compressor unit for the sprinkler system, a motor-generator set to supply current of the proper voltage for welding, two bilge pumps to raise the sewage to the necessary level and a triplex pump to circulate water through the type-casting machines.

For heating the building, two water-tube boilers, each able to serve 10,000 sq.ft. of radiation, supply steam at a 5-lb. pressure to a vacuum system having 16,000 sq.ft. of radiation. A steam plant was first considered, but because of the low efficiency in summer, of insufficient exhaust steam to supply the heating for at least part of the winter, and because gas was needed in the shop, the present plant appeared to be the best, considering its brief period of operation, and nothing has happened to gainsay this decision. The gas for both services has given satisfaction, and, from the meager data available, the cost has been exceptionally low.

C. R. Murray is the general superintendent of the works and O. G. Schmitt is the mechanical engineer for the company.

PRINCIPAL EQUIPMENT OF BARNHART BROTHERS & SPINDLER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Gas generators	Water sealed	8 ft. dia, 12 ft. high	Produce gas for heating and power	Atmospheric pressure in top of producer	Flinn & Dreffein Co.
2	Economizers	Counterflow	42 in. dia., 9 ft. high	Heat air to generator	Gas 1200 deg. F., air 500 deg. F	Flinn & Dreffein Co.
1	Scrubber	Wet	78 in. dia., 22 ft. high	Clean gas	Coke, water and excelsior	Flinn & Dreffein Co.
1	Boiler	Vertical fire tube	15 hp.	Steam to generators	50 to 80 lb. pressure	S. Freeman & Sons
1	Coal hoist	Electric	1 ton	Coal from bunker to generators	Motor driven	Sprague Electric Works
1	Blower	Positive	No. 5	Gas under pressure to burners	Belted to motor, 400 r.p.m.	B. F. Sturtevant Co.
1	Motor	Direct current	15 hp.	Drive blower	220 volts, 800 r.p.m.	Crocker-Wheeler Co.
1	Gas engine	Tandem, four-cycle	125 hp., 17¼x16 in.	Main generating unit	Producer gas, 250 r.p.m.	Alberger Gas Engine Co.
1	Generator	Direct current	75 kw.	Main generating unit	110-220 volts, 250 r.p.m	Crocker-Wheeler Co.
1	Gas engine	Twin tandem	250 hp., 17¼x16 in.	Main generating unit	Producer gas, 250 r.p.m.	Alberger Gas Engine Co.
1	Generator	Direct current	150 kw.	Main generating unit	110-220 volts, 250 r.p.m	Crocker-Wheeler Co.
1	Pump	Centrifugal	1½ in.	Cooling water for gas engines	Motor driven	Goulds Mfg. Co.
1	Motor	Direct current	5 hp.	Drives circulating pump	220 volts, 2200 r.p.m.	Imperial Electric Co.
1	Air compressor	Vertical	3x3½ in.	Starting gas engines	200 lb. pressure, 400 r.p.m	Gardner Governor Co.
1	Motor	Direct current	3 hp.	Geared to air compressor	220 volts, 1300 r p m.	Crocker-Wheeler Co.
1	Motor	Direct current	75 hp.	Drive welding generator	220 volts, 1050 r.p.m.	Crocker-Wheeler Co.
1	Generator	Single-phase A.C.	50 kw.	Current for welding	150 volts, 1050 r.p.m.	Thomson Electric Welding Co.
1	Balancer set			Balance three-wire system	50 amp., 110 volts, 1650 r p.m.	Crocker-Wheeler Co.
1	Pump	Triplex	6x9 in.	Water to sprinkler system	Geared to motor	The Lucas Pump Co.
1	Air compressor		8x3½ in.	Air to sprinkler system	Geared to motor	Allis-Chalmers Co.
1	Motor	Direct current	25 hp.	Drives pump and air compressor of sprinkler system	220 volts, 1650 r.p.m.	Sprague Electric Works
1	Pump	Triplex	5x6 in.	Cooling water for casting machines	Chain drive to motor	The Deming Co.
1	Motor	Direct current	5 hp.	Drive triplex pump	220 volts	Sprague Electric Works
2	Pumps	Bilge	No. 5	Raise sewage	150 gal. per min., 30 ft. head, motor driven	Chicago Pump Co.
2	Boilers	Low-pressure, water tube	10,000 sq.ft. radiation	Heat building	5 lb pressure	Hart & Crouse Co.
1	Pump	Vacuum	5x7 in.	Heating system	Belted to motor	Warren Webster & Co.
1	Motor	Direct current	4 hp.	Drive vacuum pump	220 volts, 1150 r.p.m.	Sprague Electric Works

Boiler Feed-Water Expurgator

A system for the purification of water for boiler purposes has been placed on the market recently. To obtain the catallactic action, the treating member, known as the expurgator, is placed in the feed pipe, preferably between the heater and the boiler. The water passes through the large connection on the upper left side of the expurgator into a channel, Fig. 1, which, becoming smaller on approaching the bottom, increases the pressure of the water until it arrives at the bottom or narrowest point. There the water is at its highest pressure and comes in contact with the protruding lip of the left wall of the hopper, thereby causing a rotary suction back of the lip.

This suction draws a continuous stream of treating material, consisting of granulated particles of metal known as granx, from the hopper through the small opening at the bottom into the water. Owing to the high pressure, the granx is agitated until it emerges from the channel. When the water is diverted by a curved deflector on the top of the outside wall of the channel with the center of the hopper, where the granx, having been carried by the water, fall by their own weight back into the hopper, thereby preventing the same from continuing in the outflow into the boiler.

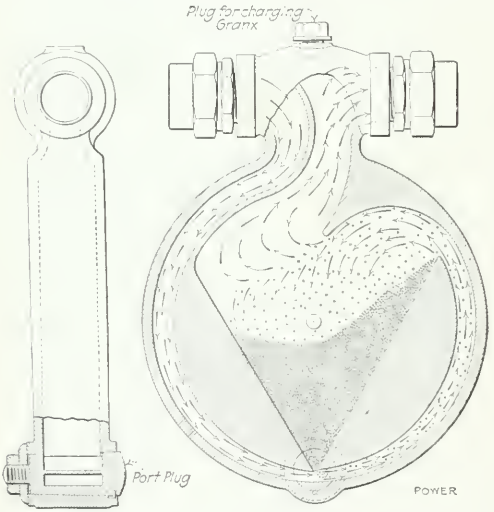


Fig. 1. Section through Body of the Expurgator

About every thirty days the expurgator is charged with granx through a small hexagon plug at the top. The treated water passes into the boiler and the impurities and substances are brought to the surface by the water circulating in the boiler, where the skimmers, Fig. 3, draw in these impurities and foam through perpendicular pipes into the settling chamber.

These skimmer heads are shaped according to the type of boiler in which they are used, and somewhat resemble a flattened megaphone. The lower side of the skimmer head is always sumberged and the upper side open, to pick up all impurities brought to the mouth of the skimmer by the water. Owing to the height of this opening, the water may rise or fall the limit of the boiler without affecting the skimming operation.

On passing through the pipe into the settling chamber, the water enters the large receiving pipe surrounding the return pipe and, going down the outside, comes in contact with an inverted cone, which diverts the heavier-than-water substances out toward the side of the settling chamber, while the lighter-than-water substances pass upward to the top. The heavier substances continue to fall, passing a second cone at the head of the return pipe and, being diverted to the sides, settle to the V-shape bottom of the settling chamber Fig. 2.

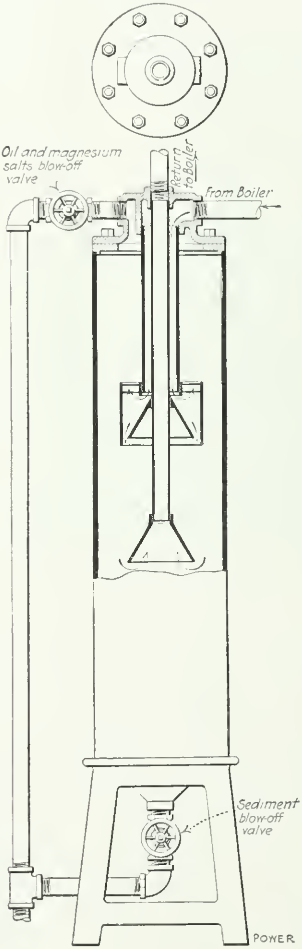


Fig. 2. Settling Chamber

The clean water travels through the center of the lower inverted cone and into the middle or return pipe, and back into the boiler. This circulation is constant, and the suction is not great enough to return the substances or foreign matter, which are constantly settling to the bottom of the chamber where the accumulation can be blown off.

The valve at the top allows blowing off the lighter-than-water substances in the same manner; it can be done whenever the amount of sediment found demands it.

As the system is automatic, it requires no attention. An expurgator capable of handling up to 250 hp. is about 18 in. across the face and 4 in. thick; it can be placed anywhere in the feed line convenient to the boiler. The settling chamber is about 16 in. in diameter, about 6 ft. high, and can be placed at any of the small places about the boiler.

In the catallactic action brought on through attrition, old scale is attacked from its surface and is softened slowly. The boiling water removes this softened surface through friction in particles which are picked up by the circulation and carried to the mouth of the skimmer head, and through it to the settling chamber.

The purpose of the system, which is built by the Water Expurgating Co., 42 Broadway, New York City, is to saturate the water through attrition, thereby causing the desired catallactic action, thus preventing any of the scale-forming substances from adhering, when they pass into the boiler.

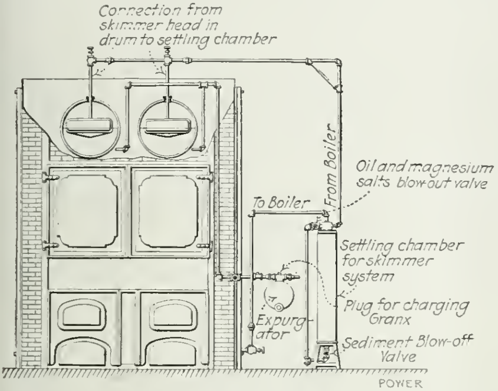

Connection from skimmer head in drum to settling chamber
From Boiler
Oil and magnesium salts blow-out valve
To Boiler
Settling chamber for skimmer system
Plug for charging Granx
Expurgator
Sediment Blow-off Valve
POWER

Fig. 3. Arrangement of Skimmer, Expurgator and Settling Chamber

New Combined Thesis

By Perry Cassidy*

The complete design of a 15,000-kw. power plant has been finished as a thesis by the 1914 class of the College of Mechanical and Electrical Engineering, State University of Kentucky.

The problem of the location and design of such a station to furnish light and power to the mining districts of eastern Kentucky and for manufacturing and lighting in the central part of the state, was taken up in conjunction with the class in power-plant design early in January. After careful study, it was found that Valley View, on the Kentucky River, would be an ideal load center, but the cost of shipping coal from the eastern fields of Kentucky would be $1.25 per net ton. The question then arose whether it would not be more economical to build the plant in the center of the coal fields and use a high-tension transmission system to bring the current to a small central switching station at Valley View.

Upon investigation, Hazard, in Perry County, was found to offer good facilities for the plant. There are several large coal mines a mile or two from the town, the Lexington & Eastern R.R. and the north fork of the Kentucky River meeting at that point. The yearly cost of a transmission line from Hazard to Valley View and a switching station at Valley View was found to be sufficiently less than the difference in cost of fuel at Hazard and Valley View to warrant the building of the plant at the former place.

In March, the senior class was sent to Hazard to make an investigation of conditions affecting the design of a power plant. A report was made by the students on the quantity, quality and cost of available coal, quantity and quality of water, weather conditions, available building material and advisable site for the plant. The report was supplemented by photographs of the river, the site selected, the coal tipples, railroad and other general views.

The site is on the bank of the river near the railroad, and about one hundred yards from the tipple of one of the largest mines, so that coal could be taken in dumping cars directly from the tipple to the boiler room.

Work was started on the actual design of the plant Apr. 1, the men being required to draw eight hours a day, and three hours overtime two nights a week. Moreover, a time-clock system was used to record each man's time and the time on each drawing, and penalties were imposed for lateness and absence. Each man was given at least one building, one piping, and one electrical drawing, and also some specification work.

The time required to complete all the drawings and all specifications was 5673 hours, an average of 56.73 hours per drawing. This compares favorably with the time required in a consulting engineering office.

One hundred drawings were made, checked and the specifications written for building construction, all equipment, piping, wiring, etc. Excellent coöperation was secured from the manufacturers of power-plant equipment, the design being considered as if a *bona fide* one, drawings, specifications and quotations being furnished in the usual manner. It was estimated that the plant as designed could furnish power at the switchboard for less than five mills per kilowatt-hour.

The plans call for the coal to be received in the coal house and either dumped into the crusher hopper or handled by a bucket crane. From the crusher the coal is taken on a belt conveyor to a bucket conveyor, which elevates it to the bunkers over the boilers.

The boilers selected were 800-hp. B. & W., set singly, with chain grates, the steam conditions being 190 lb. pressure and 130 deg. superheat. Seven boilers are specified with room for three more.

Three 5000-kw. horizontal turbo-generators operating at 6600 volts are specified for the turbine room, with room for one more; the turbines to be installed in units of two, with one open feed-water heater, two feed pumps, two turbo-circulating pumps, one motor-driven exciter, one turbine-driven exciter, and other minor equipment for each two turbines.

In the switch house and gallery are located the switchboard, and low-tension apparatus, office, toilet room and store room.

All high-tension (110,000-volt) transformers, switches, protective apparatus, etc., are located outside the building on a concrete foundation with steel framework.

From the results obtained, it is thought that the combined thesis is of more benefit than the individual one. Although the principle of the individual thesis is sound, it is doubtful whether theses when conducted as in the past are of the greatest education and technical value. The time given to the undergraduate thesis is necessarily short, and in order to derive results that will appear to have some importance, the student usually takes a problem that is either too complex to be handled in the time available, or is too large for him to fully comprehend.

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Testing Polarity of Field Coils

By F. A. Annett

After the field coils have been taken out of a motor or generator for repairs or rewinding, unless they were carefully marked, the electrician is confronted with the problem of getting them back in the machine with the proper polarity. In many cases, the method of procedure is to first place the coils in the machine and connect them up temporarily; then test the pole-pieces for the proper polarity, but this is accompanied usually with considerable labor, for if the electrician is unfortunate enough to have a number of the coils of the wrong polarity, considerable unnecessary labor is involved in removing and reversing them.

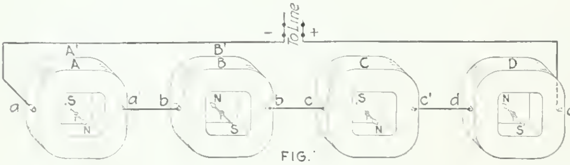


FIG. 1

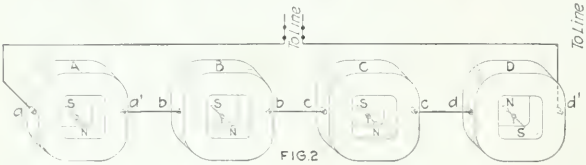


FIG. 2

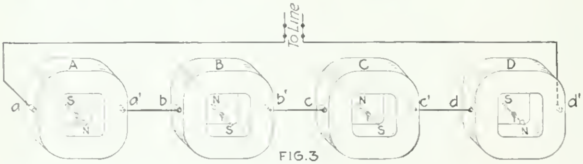


FIG. 3

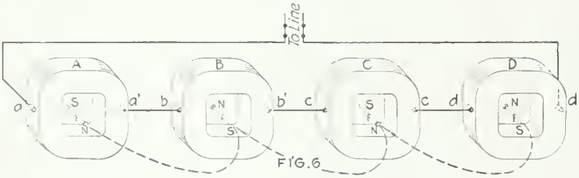


FIG. 6

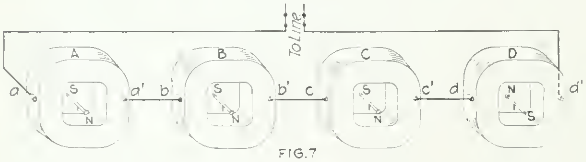


FIG. 7

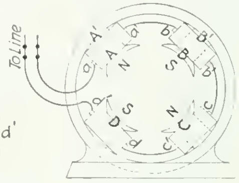


FIG. 4

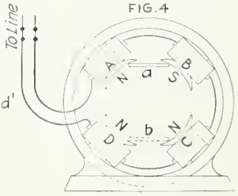


FIG 5

How to Determine Polarity of Field Coils by the Use of a Compass or a Nail

A better method is to test the coils before they are placed in the machine, which may be done as follows: First, place the coils and connect them as in Fig. 1, then after closing the switch to the line, test the coils with a compass for the proper polarity. The compass should point alternately north and south in adjacent coils, as indicated in Fig. 1. If a condition is found like that shown in Fig. 2, where three adjacent coils are of the same polarity—that is, *A*, *B* and *C* are north poles, change coil *B* end for end or interchange the connections on it. This method means that coil *B* will have to be revolved through one-half revolution to bring the coil terminals in the proper position to make the connections.

Again, consider a condition as that in Fig. 3, where coils *A* and *B*, *C* and *D* are alternate north and south poles, but adjacent coils *A* and *D* are north poles and coils *B* and *C* are south poles. To remedy this condition, it will be necessary to change coils *C* and *D* end for end or interchange the connections on them to bring the four poles into the proper polarity. After the desired condition has been obtained, the coils may be placed on the polepieces just as they are located, as indicated in Figs. 1 and 4. After the coils have been located on the polepieces, they may again be tested with a compass to see if the work has been done properly.

When testing for polarity with a compass, care should be taken to always so hold it that the needle is free to move, for if the compass is shifted from one polepiece of opposite polarity, if the needle is not free to move, the polarity of the needle will be reversed and will indicate that the fields are of the same polarity; this might lead one into considerable trouble. A good plan is to make the test two or three times so that the chances of making a mistake will be reduced to a minimum.

Another convenient way to test the polepieces for the proper polarity is with a piece of iron, long enough to reach from one polepiece to another and placed as shown at *a* in Fig. 5. When the poles are alternately north and south, as at *a*, the iron will be strongly attracted; if both polepieces are of the same polarity, as at *b*, the attraction for the piece of iron will be very weak and it will be repelled when brought close to the polepieces. Care should be taken not to mistake the weak attraction which two like poles have for a piece of iron when brought in contact with them, for the strong pull two unlike poles will exert on the same piece of iron.

A good plan is to try the pull between any two poles, and if it is not very strong, interchange the connections on one coil. If the pull is increased the polarity is correct, and if decreased, the polarity is wrong and the coil leads that were interchanged should be changed back.

When a compass is not at hand for making the test as described in Fig. 1, a wire nail may be used for the purpose as indicated in Fig. 6. After the coils have been energized, if the nail is placed in one of them it will be magnetized and retain enough of the magnetism to act as a compass needle. Care should be taken in using it as the magnetism will be easily reversed in it. Furthermore, it should be moved from one coil to another in the curved line as indicated by the dotted lines in Fig. 6. If the coils are of the proper polarity, the nail will point in the opposite direction in adjacent coils. If two adjacent poles are of the same polarity, the nail will point in the same direction as shown in Fig. 7, which can be corrected as in Fig. 2.

Operating Underfeed Stokers

By J. C. Hawkins

SYNOPSIS—The formation of clinker at the side walls and extending nearly halfway across the furnace, a serious trouble. Oyster shells prevent the clinker from fusing with the firebrick. Clinkers of New River slack less troublesome than clinkers from Georges Creek slack. Banked fires sometimes cause wind box and tuyere plates to warp.

*

In the operation of an underfeed-type stoker plant during the past four years the writer has experienced many difficulties. Some have been easily overcome, and others made less troublesome by experimenting with different methods of operation. One of the greatest troubles has been with clinker sticking to the side walls of the furnace. The stoker used is supposed to be self-cleaning, by pushing the clinker down onto the dump plate, and in a measure it performs this work successfully. All the coal used in this plant is bought on the B.t.u. basis, and one year the contract called for Georges Creek mine-run coal. This was usually of a good quality but it formed a clinker that adhered to the side walls of the furnace, and would sometimes extend nearly a third of the way across the furnace, and when the load was extra heavy would bridge entirely across to the center tuyeres; there being three tuyeres in each furnace, this clinker would be from 8 to 14 in. thick. When properly operated the stokers make no smoke even when forced, except when working the fire, either barring or cleaning, at which time they will smoke, and, on account of the rigid smoke laws it is necessary to clean the fires after dark and before daylight, twice during the 24 hr. being sufficient.

Cleaning the Stoker Fire

To do this the fire is burned down as low as the condition of the load will permit, and the clinkers ripped off the tuyere plates and pushed down onto the dump plate. When using Georges Creek coal the only way to get these clinkers off is with a 12-ft., $1\frac{1}{4}$-in. steel bar having a chisel point, the bar being driven with a 12-lb. sledge hammer. This heavy pounding loosened the side walls which soon had to be rebuilt. A better grade of firebrick was used, but did not stop the trouble. Next, oyster shells, which are very cheap here, were used to prevent the clinkers from sticking to the walls. After the fires were cleaned about three or four scoopfuls of the shells were thrown next to the wall on each side of the furnace. The idea was that the lime in the shells would form a flux which would prevent the clinker from sticking. This did much good in keeping the clinkers from sticking, and seemed to make them more brittle. The next year New River mine-run coal was used and did not give as much trouble in sticking to the walls as did the Georges Creek coal. Sometimes slack was sent in place of mine-run, at such times the clinker was exceptionally bad, although with New River slack oyster shells were not needed in such quantities as with Georges Creek slack.

In addition to the chisel bar the tools most useful are a 11-ft. slice bar for ripping up soft clinkers and breaking up the fire bed, an 11-ft. hoe for pushing the loose clinkers down onto the dump plate, a long hook to pull out the clinkers that form on the center tuyeres, the hook being used from the side door. Another handy tool is a 10-lb. sledge hammer with a 11-ft. iron handle. Sometimes the side-wall clinkers may be allowed to become cool at which time they can be broken off with the long-handled hammer. This method of getting the clinkers off injures the walls, but they must be got off some way, and experience has shown this way to be the best. In cleaning the fires, after the dirt and clinkers are pushed back onto the dead plate, they are allowed to lie there an hour or two. This gives the coke that may be pushed along with the clinkers a chance to burn, thereby preventing it from being dumped into the ashpit.

Several kinds of bituminous and semibituminous coals have been tried, all of which gave some trouble by clinkers sticking to the side walls. The New River crushed mine-run seems to clinker less than any coal tried in our plant.

Some kind of a water back could be used in place of the firebrick side walls. Such a water back would have to be connected to the boiler, and would not be very long lived as the temperature at this point is extremely high, but it would prevent the clinker from sticking, and would increase the capacity of the boiler to some extent.

Clinker Destroys Walls

Several kinds of firebrick have been used with the hope of getting one that the clinkers will not stick to; even a cement wall was tried. This wall was made of cement, sand and gravel. It did not last long as it cracked and broke away in pieces, and the clinkers seemed to stick to it as badly as to the firebrick walls.

Another difficulty was to get the right proportion of air and coal. The stokers are driven by the fan engine through a chain drive. When the steam pressure is up to standard the fan and stoker run very slowly. Then when the pressure drops one or two pounds the engine speeds up giving a greater air pressure, and pushing the coal faster. The speed is controlled by the damper regulator. Several changes in the shaft gears were made before a speed was found that would give the best speed of the stoker in proportion to the fan speed. If the stoker ran too fast when the load was light, and the engine was running slow, the furnace would become full of green coal. If it ran too slow the fire would be too light. and when the fan did speed up an excess of cold air would be forced through the thin fire on the tuyeres carrying a great deal of heat to the stack. The best method of controlling the speed of the fan engine is to have it run at a constant speed to be determined by the conditions of the load. That is, a light load would require a slow constant speed, and a heavy load a higher constant speed. We tried setting the governor to give the desired speed so that the engine would run constant, the damper regulator being set to operate only in an emergency, and while the coal consumption was lowered, it was necessary to change the speed every time the load changed. This the firemen would not do as long as steam pressure was up and consequently in times of light load far too much air was used so that one saving was offset by another waste. If all the firemen could be trained to change the speed with changes of load, this plan would work all right. Eventually some system will be devised whereby the control will be automatic and at a constant speed as required to maintain the pressure.

One improvement that proved to be valuable was in taking the air for combustion from over the tops of the boilers. This increased the air for combustion about 90 deg. F., and also gave better ventilation to the room. This was done by building a wall around the fan open only to the space over the boilers, and having suitable doors to make all parts of the fan and engine accessible.

Coal Got Into Air Duct

Another trouble was with the wind box which became warped and cracked. Green. partly burned coal got through the cracks and through a broken tuyere plate into the air duct. This duct was galvanized iron leading from the air tunnel to each separate stoker, and the hot coal that got into the duct continued to burn, causing it to get red hot. The only way to get it out was to stop the fan, get into the tunnel through a manhole, crawl along to the branch, scoop up the fire and bring it out through the manhole. It took a very careful examination to find out how the coal got into the air duct, but it was learned that the warped and cracked wind box was caused by leaving the fire banked several days. In fact, more damage was done to the furnace the first year by banking fires than in the other three years put together, because the firemen were not familiar with the type of stoker. We find it possible to bank the fire for a day, but if left longer than that serious warping is likely to result.

To bank the fire it first should be cleaned, then close the damper in the air duct, and let the stoker run until a large amount of coal is pumped into the furnace. Next throw out the clutch, and partly close the stack damper. If the fire is to be kept banked for more than one day more coal must be pushed in to keep the fire from burning down to the tuyere plates and wind box, which are of cast iron, and if the fire reaches them they will become red hot, and either warp or crack, allowing green and partly burned coal to get into the wind box, also the tuyere plates will not fit tightly.

The air pressure in the wind box is regulated to suit the demand for steam. In cold weather when the load is heavy the speed of the fan engine is set by adjusting the governor to give a maximum air pressure of 2½ in. of water in the wind box. During this time the load sometimes reaches 200 per cent. of the rated capacity for a few hours. During the summer when the load is light and steady the maximum air pressure is set at 1½ in. of water.

Putting the Fire Out Quickly

In all boiler plants there are times in emergency when it is necessary to get the fire out as quickly as possible. For instance, in case of a broken handhole plate or burst tube, or low water. These furnaces when in full-load operation contain about a yard and a half of coal and fire, the fire. of course, being on top. In a case of this kind it is best to open the dump plate, close the air blast but leave the stack damper open, then turn the water hose on the fire, and push it into the ashpit with the hoe where it may be quenched. In one instance a hand chemical fire extinguisher was used with good results instead of water. In using water on the fire, care should be taken to keep it off the firebricks as it will make them crack. It is not good practice to turn water into the fire, but when a large quantity of fire must be got rid of as quickly as possible, drastic measures must be resorted to. If it is only necessary to put the fire out for a short time as in case of broken tube cap or low water, a little of the fire may remain without damage. After the cap is replaced and the boiler filled, the fire can be quickly started by turning on the blast and starting the stoker. A new fire may be built in much less time than is good for the boiler. The easiest way is to clean out all clinkers, pieces of brick, etc., after repairing. Then pump up a good head of coal, generally about two hoppers full. Next throw in a few pieces of wood, barrel staves, boxes, etc., piling them close to the front doors. Then put greasy waste under the wood in the doorway and set it on fire. The damper and front doors should be left open for a few minutes but the air blast left closed until the wood is burning well, then open the air blast a little, close the door and start the stoker. The fire may then be forced as fast as desired.

The underfeed type of stoker gives such an intense heat when being forced with a high air pressure that if used under a water-tube boiler especial care must be taken to keep the tubes clean and free from scale. If this is not done the tubes will be bagged very quickly. In handling these furnaces the firemen hardly realize the difference between a 50 per cent. load and a 150 per cent. load unless they shovel the coal into the hoppers by hand, but unless properly handled the stokers will waste as much coal as when firing by hand. This is usually due to excess air, and dumping good fire with the clinkers.

In this plant the smoke problem even when running at 200 per cent. overload has given little trouble but our neighbors are complaining of the fine ashes that are blown out of the stack when high forced draft is used. This trouble is, of course, much worse than it would be if only natural draft was used, and does give the white granite buildings a dirty appearance. This may be stopped in at least two ways. One is to place a series of closely set V-shaped baffles in a large chamber between the boiler and the stack, or by using a water curtain or cinder arrester.

Lagonda Fire-Tube Boiler-Turbine Cleaner

In Fig. 1 is shown a new air- or steam-turbine-driven vibrator knocker head for dislodging scale from the outer surfaces of return-tubular boiler tubes. At the same time, the soot from the inner surfaces which is loosened by the knocker, is blown out of the tube ahead of the cleaner by the exhaust from the turbine.

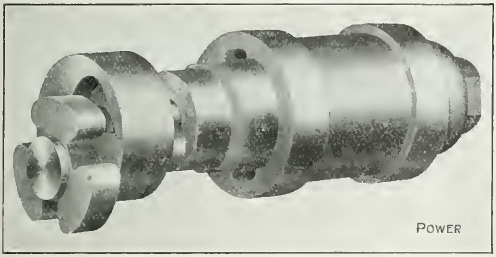


Fig. 1. New Turbine-Driven Vibrator Head

The head, also shown in Fig. 2, has a cylindrical body, somewhat smaller in diameter than the boiler tube, and an eccentrically pivoted lever carrying a clover-shaped knocker on a stud at its free end. The lever fits flush into a triangular recess in the forward face of the main body, the free end swinging in an arc through the center of the head.

The three hammer faces of the knocker are shaped to fit the inner circumference of the boiler tube to give a large area of contact.

As the head is driven at a high speed, the eccentrically pivoted lever carrying the knocker is thrown from side to side and the knocker is caused to revolve on its axis at each contact with the tube, giving a resultant whirling motion to the knocker and causing it to hit all of the tube. The cleaner, made by the Lagonda Manufacturing Co., Springfield, Ohio, is fed into the tube by a flexible rubber hose.

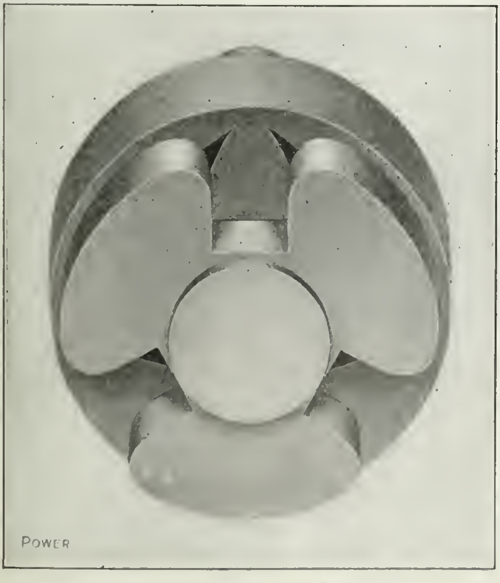


Fig. 2. End View of Knocker Head

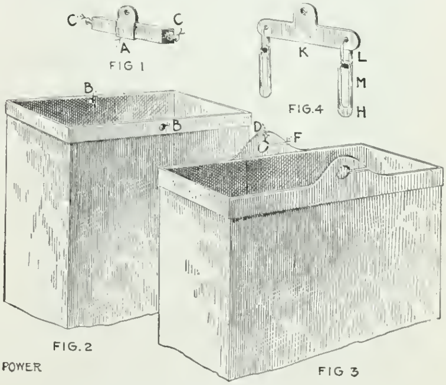
The motor for driving the head is of the rotary-engine type. Air or steam, striking radial paddles, revolves the shaft and holds out the paddles to form a tight fit with the casing. There are four paddles, two of which are always under pressure.

*

Suggested Improvement for Lifting Ice Cans

By Robert Grandon

There has been but little improvement made during the past few years in the method of engaging ice cans to lift them from the brine bath. The method generally used, that of the spring can dog *A*, Fig. 1, engaging the holes *B*, Fig. 2, in the sides of the can, is crude; it has caused many ammonia leaks and been the means of injuring the foot of the ice puller. The small shoulders *C*, Fig. 1, soon wear off, so that if the can spreads or there is a little carelessness by the ice puller, the can and ice drop. Should the can with its ice go back into the brine bath, it will probably strike a coil and start an ammonia leak; should the puller be lowering the can into the dump, his foot is mashed or his leg bruised.



Old and Proposed Arrangements for Lifting Ice Cans

In an effort to start something in the way of an improvement, the writer offers a suggestion. It would increase the first cost of the can, but pay in the long run, if it should stop the dropping of the cans.

In Fig. 3, the bond in the can is made with a hook arrangement, shown at *D*; the slot *F* slopes downward slightly from the hole at the center. In Fig. 4, the single tree *K* has small chain links *L* at the ends and in these are the engaging links *M*, which have the lower end *H* elongated (for wear) and flattened to pass through the slot at *F*. It would be necessary to make these links long and narrow, as shown in the sketch, and of about $\frac{5}{16}$-in. iron to hook on the can when in the brine bath. It might be necessary to trim the woodwork a trifle to make room for the link to pass. In any event, the result obtained would be worth the trouble and expense.

Deformation of Welded Drums

By J. E. Terman

Many readers will remember a paper of much interest by S. H. Barraclough and A. J. Gibson, on the stresses in unsymmetrical boiler joints, an abstract of which was published in Power of Apr. 15, 1913. Mr. Barraclough, in conjunction with H. A. Rorke, has made similar experiments on autogenously welded drums or barrels used for transporting sulphuric acid and read a paper on the results of these tests before the Engineering Association of New South Wales, an abstract of which follows:

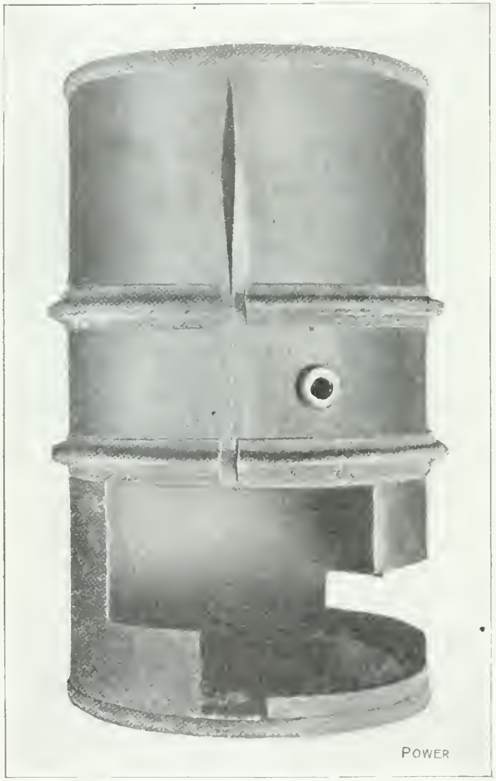


Fig. 1. Drum A, Showing Failure of Longitudinal Weld

The drums were of thin steel plate, about $\frac{1}{10}$ in. thick; the general construction is shown in Fig. 1. This drum failed while being handled on a dock, evidently the result of an accumulation of pressure of gas resulting from the action of the acid on the material of the drum. A man was killed as a result of this accident.

These drums were formed by welding the parts with an oxyacetylene flame, the welds being made without any special preparation of the joined edges, except to shear them straight and butt the edges together; no other material was added as is customary in welding very thin plates. It will be noted that there are two bands or hoops around the drums, these being formed separately and welded to the shell as well as together at the ends after passing around the drum.

In order to determine the general efficiency of welds made by the oxyacetylene process, a specimen of plate about 2 in. wide and ½ in. thick was carefully welded and tested, as was also a piece of the solid plate from the same sample. These test pieces are shown (Fig. 2) as they appeared after being broken, A and B representing respectively the solid specimen and the one which was welded. The results of the tests are given graphically in Fig. 3, where the letters on the curves correspond to those given on the test pieces in Fig. 2. This test proved that the total elongation in the case of the solid plate was 33.7 per cent. against 5 per cent. for the welded specimen, the ultimate strength of the solid plate was about 57,000 lb. against 48,000 lb. for the welded plate. It will be noted from Fig. 3 that the behavior of both specimens was about the same, within the elastic limit. These results show a percentage of strength for the welded joint of about 77 per cent. The authors point out that claims are often made that the strength of autogenously welded joints is greater than that of the solid plate, but in their experience such claims are without foundation. Where results are obtained which indicate that the weld is stronger than the solid plate, it is probably due to the metal being piled up at the weld so that its thickness at the joint is greater than in the solid plate.

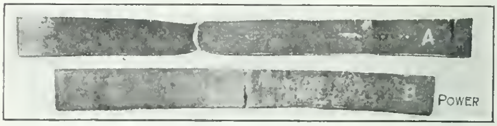


Fig. 2. A, Unwelded Test Piece; B, Welded Test Piece

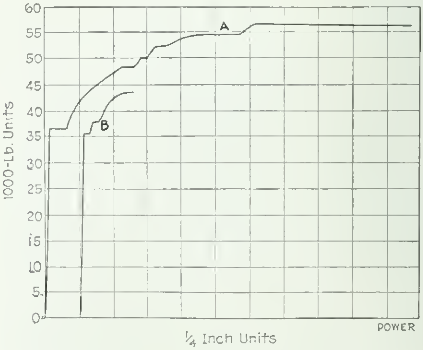


Fig. 3. Stress-Strain Diagram of Test Pieces A and B

Reference was made to a series of tests of oxyacetylene welds made at the University of Illinois by H. L. Whittemore and reported in bulletin No. 45 of the university, where it is shown that in the test of eleven such welds the percentage of efficiency ran from 64.4 to 86.6 per cent., from which it was concluded that the maximum efficiency that could be expected for such welds was 85 per cent.

The drum shown in Fig. 1 failed through the longitudinal seam, the rupture occurring near the top end. The hoops have been cut away at the joint so that the entire length of the welded seam can be seen. Since the tensile strength of the shell was about 57,000 lb. per sq.in., it was estimated that the bursting pressure, without considering the effect of the hoops or heads, would be about 450 lb. for the solid plate; and allowing an efficiency of 50 per cent. for the welded joint and a factor of safety of five, the safe working pressure would be about 45 lb. The manufacturers of these vessels placed a test pressure on them of 60 lb., and the authors considered this about right. Measurement of the strains on the surfaces of such drums as will be described presently showed that the usual methods for calculating the strength of structures of this kind are incorrect.

Destructive tests made on a number of drums constructed like the one which exploded, showed that when a pressure of about 85 lb. was reached the heads began to bulge, and at 100 lb. both heads had reversed and became concave to pressure. The welded head seams started to leak at 105 lb. on practically all the drums tested, and while the longitudinal seam was the point which appeared to be the weakest part on the drum which failed, such seams were generally much stronger than the head seams. Six drums were examined in all, one of which was the drum causing the accident. Drum *F* of this lot, after having measurements made of the distortions on its surface due to the internal pressure, was submitted to a destructive pressure test. At 105 lb., when the head seam began to leak, the longitudinal seam was hammered to see how it would stand such abuse under pressure. Owing to some peculiarity in the construction of this drum, the shell along the longitudinal seam was in compression rather than in tension, and after several blows with a machinist hammer had started the seam to leak, a slight rise in the pressure applied would stop the leaks; this experiment was repeated a number of times with the same result. Several pressure tests were made on drums similar to drum *F*, but none of these indicated compressive stresses in the shell except in spots where the surfaces had been dented or otherwise deformed.

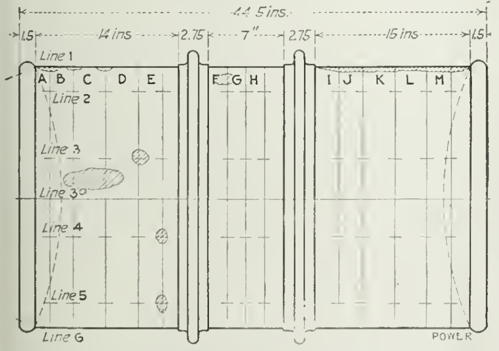


Fig. 4. Drum *F*, Showing Longitudinal Test Lines 1 to 6 and Circumferential Lines *A* to *M*. Shaded Areas Represent Dents

The final conclusions of the authors regarding the use of autogenous welds for the longitudinal seams of such vessels were that they should be able to withstand the strains of ordinary use. That the concave head bulged at a pressure considerably under the bursting strength of the cylindrical portion of the drum, seemed to indicate that this form of head was in the nature of a safety valve, and by increasing the capacity of the drum in the act of reversing, it would make the vessel safe from explosion for a longer time than a head of more rigid construction.

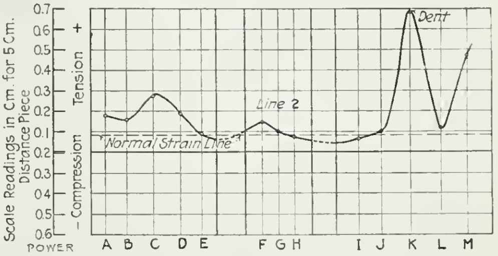


Fig. 5. Strains along Line 2

While it was believed from the results of the tests that the actual efficiency of the welds, where they extended entirely through the thickness of the sheets, was something like 80 per cent., it was found that practically none of the joints was thus perfectly welded and, owing to this fact, it was considered safe to allow an efficiency only of 25 per cent. for such joints. With these values for the efficiency of joint and with an actual factor of safety of 5, the factor of safety to be applied in reference to the strength of the solid plate would be 20, which was considered by the authors to be about the right figure when the risk to life was considered.

In order to estimate the stresses in the different parts of a drum while under pressure, the semi-circumference of drum *F* was divided into six equal parts by longitudinal lines 1 to 6, as in Fig. 4. Line 1 is along the welded joint and there is also an extra line, 3a, placed on the center diameter. In addition to the longitudinal lines, circumferential lines *A* to *M* were drawn as shown. Measurements of the longitudinal and circumferential deformations of the shell when under an internal pressure of 30 lb. were made at each of the intersections of the lines just mentioned. Fig. 5 gives the results obtained in a longitudinal direction along line 2 in Fig. 4. It will be noted that, while all the plate is in tension along this line, the deformations are by no means regular and that they are tremendously increased by a dent on line *K*.

In Fig. 6, the circumferential deformations as found under 30 lb. pressure are plotted on each side of the vertical diameter, although the results plotted on this figure apply to the measurements on one side of the drum *F*, along the lines *A*, *C*, *D* and *E*, in Fig. 4. The deformations over the surfaces of the drums were measured by means of Martens extensometers, the distance pieces of which were about 2 in. long. In making the measurements, the pressure was raised from 0 to 30 lb. and then lowered again to zero, readings being taken at each 5-lb. change of pressure, both while the pressure was being raised and lowered. The values given in Figs. 5 and 6 represent only the readings taken at 30 lb. pressure. In Fig. 6 these values are plotted without reference to whether a tensile or a compressive stress existed at the point measured, but it is stated that the high values along the upper part of the vertical diameter in Fig. 6, which represents the location of the welded seam, are compressions and not extensions, as would be naturally expected.

While Figs. 5 and 6 give the longitudinal strains, only at right angles to each other, there are, of course, strains in all other directions and their values must lie between the two just given. In order to determine the value of the strains around a point on the shell, the distance piece of the extensometer was moved around a fixed point on the shell until it had occupied 12 positions equal distances apart around this point, measurements being taken at each point during the raising and lowering of the pressure, as was the case for the longitudinal and circumferential strains.

Fig. 7 shows the results of such measurements made at the point produced by the intersection of lines *G* and 6, as given in Fig. 4; it will be noted that this intersection is diametrically opposite the welded seam. That the extensions measured circumferentially are not twice those measured longitudinally, as might be expected, is because the strains in one direction produce contractions at right angles to them. Therefore, the high circumferential stresses produce high longitudinal strains of the opposite sign to these produced by the longitudinal stresses and *vice versa* for the circumferential strains produced by the longitudinal stresses. This explains why the curve in Fig. 7 is dumb-bell shape and not elliptical. With Poissons' ratio taken at ¼ (this ratio expressing the relation between the extensions in the direction of a stress as compared with those in a transverse direction) the longitudinal extensions would be to the circumferential extensions as 1 to 3½, and it will be noted that this is about true in the case of Fig. 7.

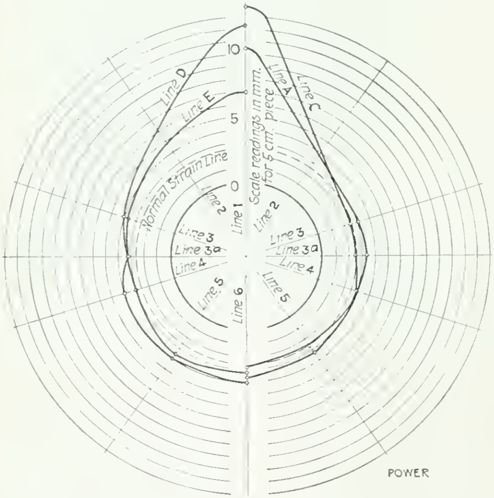


Fig. 6. Curves of Circumferential Strains on Lines *A, C, D* and *E*

Discussion

A member, referring to the safety-valve action of the concave heads, said that it would seem possible to better provide additional capacity in such drums after pressure began to accumulate, by corrugating the heads rather than bumping them. Such heads could give in, responding to an increase in pressure without so severely straining the material as would be the case with the convex form of head.

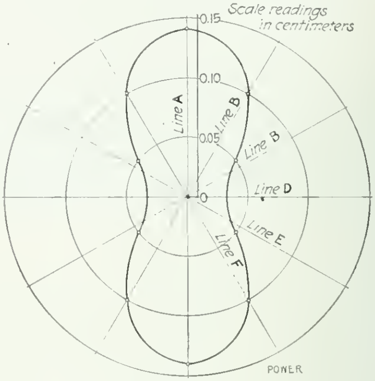


Fig. 7. Polar Diagram of Strains

It was suggested that such drums for the transportation of sulphuric acid, or for other uses where the contents might produce chemical action during transit which might cause a dangerous internal pressure, could be examined from time to time as might be found necessary, the bulging of the heads giving warning of the approach of danger. This method is said to be in use to determine if canned goods are sound, all cans with bulged ends being thrown out by the inspector as unfit for use. This member also took up the question of the improvement of welds by hammering while hot. Mr. Barraclough, in his concluding remarks, said that all such welds could be improved by hammering in the process of manufacture.

Professor Groth was quoted as stating, in a book on autogenous welding, that no one should be allowed to weld a part subject to stress until he had acquired at least two years' experience in doing such work under a competent operator. This statement is about in line with the avowed desire of the better firms doing autogenous welding in the United States; namely, to have operators for such work licensed.

The president said that as the stresses appeared to be so high at the welded joint, Fig. 6, this would require much investigation. He suggested that these figures were arrived at by assuming uniform strength for the material at all points of the drum, and that this might lead to erroneous conclusions unless other factors were considered besides the elasticity of the material. It seems improbable that the actual stresses due to internal pressure in the drum could be materially different at the seams and at other parts of the drum, unless the drum happened to be deformed at the seam so as to produce such a result.

The authors said that arrangements were being made to repeat these experiments on drums of simpler design, so as to make less complicated the comparison of results obtained with those which should be theoretically expected.

Return-Tubular Boiler Furnace Development*

By Osborn Monnett†

SYNOPSIS—The evolution of a furnace suitable for high-volatile coals from the McGinnis, Gulickson and firebrick-inclosed furnaces.

⁂

After using steam jets, the next step in the attempt to keep down smoke in the furnace of a tubular boiler was to build an arch over the combustion chamber back of the bridge-wall, somewhat as shown in Fig. 1. In connection with the steam jets the arch was an improvement as it broke up the gases and mixed them to a certain extent. However, this design lacked several essential features of a successful furnace, the principal objection being that it did not provide sufficient temperature at the point of mixture. The heat absorption into the boiler was sufficient to reduce the gas temperature to such an extent as to impair combustion of the volatile matter.

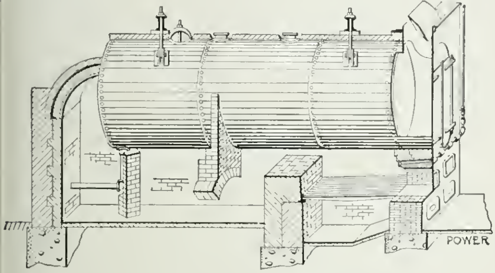


Fig. 1. Return-Tubular with Single-Span Deflection Arch

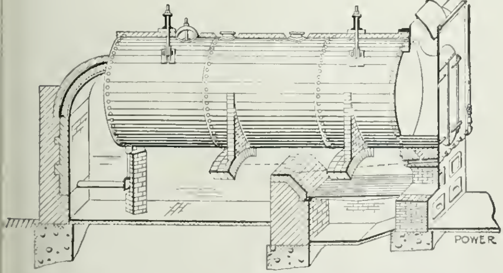


Fig. 2. McGinnis Arches in Front and Back of Bridge-Wall

An elaboration of this design was the old so called McGinnis arch setting, which was in quite common use 15 years ago. This consisted of two arches, one back of the bridge-wall and another over the grates in front of the bridge-wall, as in Fig. 2. This was an improvement over the former setting, because the gases were mixed more thoroughly and the setting gave good service until smoke began to be read more closely. A peculiarity of the setting is that the gases passing under the front arch must make one turn upward over the bridge-wall, another turn along the shell and then come in contact with the back arch, where another change in direction occurs. This will be apparent from an inspection of Fig. 2. Given careful attention, with a judicious use of the steam jets, this setting, while not considered in any sense modern, will give fairly good results. The same objection as to temperature of gases exists and detracts from its efficiency.

Another setting popular in the Middle West from 1885 to 1907 was the Gulickson, shown in Fig. 3. This consisted of a double arch over the bridge-wall with another single-span arch back of the bridge-wall. This construction split up the gases as they passed over the bridge-wall and to some extent mixed them at the second arch. Modifications of the above designs were made without number in an attempt to satisfy the public in the matter of smoke suppression. These attempts embraced various designs of so called pigeonhole bridge-walls, wing walls, piers, perforated drop arches, bulkheads, etc., but in nearly every case one or more of the essential features of a successful furnace were missing. All of the above settings were in use up to about 1907, when the subject was taken up seriously in Chicago by the Department of Smoke Inspection as at present organized.

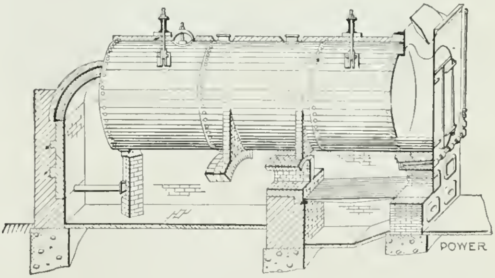


Fig. 3. The Gulickson Setting

Firebrick-Inclosed Furnaces

The best authorities at this time advised surrounding the fire by brickwork and thus maintain a high temperature to increase the ignition and provide a long-flame travel during which combustion could be made complete before the gases came into contact with the heating surface. A number of firebrick-inclosed furnaces of the dutch-oven type were built, some full extension and some half extension, but the majority were flush front, as shown in Fig. 4. At first they were built without and later with a slight drop arch behind the bridge-wall. These settings were not satisfactory, but furnished the information which led to the present ideas on hand-fired furnaces. With these dutch-oven settings the initial expense was high and a great deal of the heating surface in the shell was covered up, with consequent loss of capacity and efficiency, and the settings proved to be difficult to run without dense smoke. It soon developed that mere flame travel in hand-fired furnaces was not sufficient to produce good combustion. It was shown that even where the path of the gases from the grates to the heating surface was excessive, if there were not in this path some form of mixing arrangement that would abruptly change the direction of the gases and bring them into intimate contact, a stratification would take place and smoke would be made. The deflection arches as then built were high and accomplished imperfectly the result sought. They were afterward built lower and lower to get more positive mixture, but still there was smoke.

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†Smoke Inspector, city of Chicago.

The radiating effect from an intensely hot arch over the fire distilled the volatile matter from the fuel more rapidly than it could be mixed with air and consumed in the furnace. In fact, the furnace had a "muffle oven" effect and puffs of dense smoke were made in spite of the greatest care in operation. Finally, when it became evident that the furnace was not adapted to high-volatile coals, the arches over the fire were removed to reduce the temperature of ignition with a consequent reduction in the rapidity of distillation of the volatile matter. This resulted in a construction similar to that shown in Fig. 5, which is known as the Department No. 4 furnace, consisting of an arch sprung over the bridge-wall and extending back some 3 ft., with a deflection arch to mix the gases. This furnace increased the heat absorption into the boiler by direct radiation from the fire; decreased the rapidity of distillation of the volatile matter by reducing the igniting effect and resulted in a furnace much easier to run without smoke. A few dutch-oven furnaces equipped with special air admission have survived. They generally burn a picked egg coal and with careful attention to the air supply have succeeded in running clean.

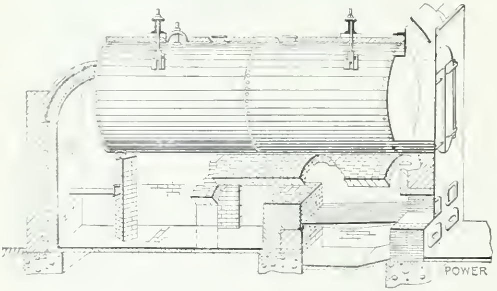

Fig. 4. Firebrick-Inclosed Furnace with Single-Span Deflection Arch

Theory of the "Cool" Furnace

Experiences with the No. 4 furnace and those that came after it gradually developed the theory upon which is founded the design of modern hand-fired furnaces as used by the Chicago Smoke Department for high-volatile coals. It became evident that ignition was not necessary to burn this kind of coal; draft was the main essential. As evidence of this, a locomotive with a plain firebox without a brick arch can burn with ease 100 lb. of coal per square foot of grate surface per hour without any ignition except that furnished by the fire itself, because the draft is adequate for the purpose.

In the next place, it was found that a "cool" furnace (one having direct radiation from the fire to the heating surface) not only increased efficiency and capacity by increasing heat absorption, but reduced the liability to dense smoke because the volume of volatile passing off was at no time in excess of the capacity of the furnace to take care of it. All that was necessary then was to provide a zone of high temperature back of the bridge-wall which would maintain the gases at or above the igniting temperature; then provide a deflection arch against which the gases would impinge at this high temperature, and finally, provide air admission over the fire in sufficient quantity to mix in the high-temperature zone with the volatile gases and furnish the necessary oxygen for complete combustion. As from 30 to 35 per cent. of the weight of the fuel is in the form of volatile gases, the air necessary to form a proper mixture must be admitted over the fire. With the ordinary drafts encountered in stationary practice, it has been repeatedly demonstrated that it is impossible to draw sufficient air through the grates to completely burn the volatile matter. The term "excess air" ordinarily applied to air being admitted over the fire, is not in any sense in excess of the air required to burn the fuel, as it must be remembered that a large proportion of the fuel is in the escaping gases and it must have this air to be completely consumed.

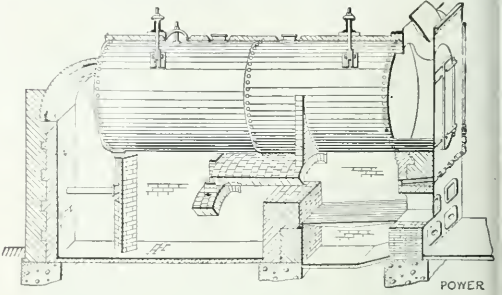

Fig. 5. Single-Arch Bridge-Wall Furnace with Single-Span Deflection Arch (No. 4 Furnace)

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Steam Pipes as Lightning Conductors—Calling attention t the splendid set of conductors for lightning protection that the steam pipes of a heating system afford the "Scientific American" suggests that they be made use of for this purpose. Under ordinary conditions the lightning cannot reach these pipes until it has punctured and probably set fire to the roof or sidewalls, and the writer declares that he has seen many buildings damaged in this way. It is, therefore, proposed that several pieces of pipe be extended up through the roof from the top floor radiators and capped at the ends.

⁂

Cost of Steam—In a report of the recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers we said that A. C. Rogers, superintendent of heating of the Toledo Ry. & Light Co., questioned a statement made by F. W. Ballard, chief engineer of the municipal electric-light plant at Cleveland at a previous meeting, that they were making 1000 lb. of steam for 10c., which would hardly pay the coal cost. Mr. Ballard explained that the 10c. per 1000 lb. of steam given in the discussion, to which exception is taken, is the value of the saving which would be made under certain conditions, this saving to be figured very conservatively. As a matter of fact, 10c. per 1000 lb. of steam is generally used in capitalization of saving, due to efficiency, when purchasing machinery, such as steam turbines, etc., as this is practically the value of the steam figure in cost of coal for its generation.

First Pacific-Built Diesel Ship

By C. A. Osier

The "Warrior," shown in Fig. 1, has the distinction of being the first Diesel engine ship to be built on the Pacific coast. Constructed at the yards of Nilson & Kelez of Seattle, for the cannery trade, it has a length of 87 ft., 17-ft. beam and 7-ft. draft, and is propelled by a four-cylinder, 120-horsepower, four-stroke-cycle, "Nlsco"* Diesel engine.

In addition to the main unit, there is a four-cylinder, 12-horsepower engine for driving the dynamo, auxiliary pumps and small compressor, and a 9-horsepower hoisting engine on the after deck. A steam-heating plant burning coal supplies steam for heating.

The two-stage compressor working on the forward end of the main shaft supplies the compressed air for spraying the fuel into the cylinders and for charging the starting air flasks. The small auxiliary compressor is for use in emergency only.

The air piping is of seamless copper tubing and the joints are not only screw threaded, but soldered to make them absolutely air-tight. The air-control valves are placed in a horizontal line across the after end of the engine, directly in front of the engineer's stand so that the entire system may be handled from that point. The small throttle valve is also located at this point and the four small globe valves which regulate the supply of fuel oil to the atomizers at each cylinder are within easy reach.

A flywheel governor is employed controlling the suction valve of the fuel pump. For running at reduced speed a hand control is employed. A balancing valve keeps the oil at constant pressure and allows any excess to be drained back to the supply tank, which holds about seven gallons, and receives the oil from the main tanks through a small rotary pump, belt-driven from the main engine.

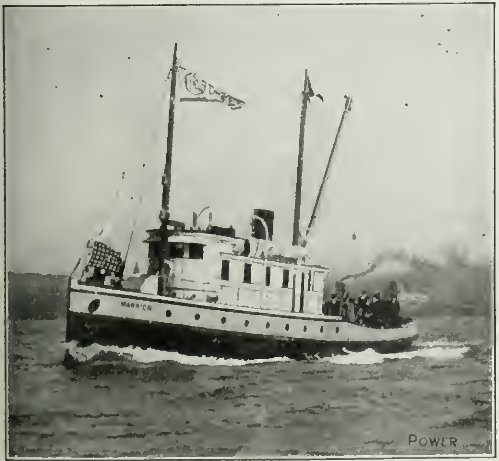

Fig. 1. "Warrior" on Trial Trip

The exhaust gases are led from the exhaust manifold along the upper port side of the engine and out through a well lagged exhaust pipe into the stack. Too much fuel oil fed to the cylinders quickly shows in a smoky exhaust, but the regulation of this oil till there is an almost imperceptible vapor from the stack has been found easy.

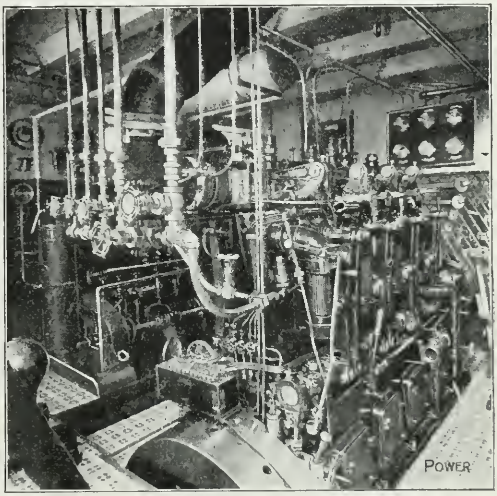

Fig. 2. Engine Room of "Warrior"

Lubrication of the engine is accomplished from two large Detroit lubricators, from several independent oil cups and from the usual grease cups, the latter being used principally on the camshaft bearings and rocker-arm pins. A very light gas-engine oil is used in the cylinders.

The lubricators are filled from bent copper piping coming up through the floor of the engine room, and supplied from a 65-gallon tank mounted above the lockers on the starboard side. This method of filling eliminates the usual slopping of oil when the tanks are replenished during rough weather. The circulating water for the engine is supplied by a centrifugal pump driven by the flywheel.

The most interesting part of the "Warrior's" performance, however, is contained in the record of her trial runs, showing the economy of the Diesel type of engine. The craft operates on Star fuel oil, and the tanks have a capacity of 1100 gallons. The price of Star oil in Seattle is 2¾ cents per gallon or $1.15 per barrel containing 42 gallons.

The trials showed a fuel consumption of 6¼ gallons per hour, which with the tanks filled will permit 224 hours' running. At a speed of 10.3 knots or 11.85 miles per hour, which was attained on the trial trip, the vessel will have a cruising radius of 2665 miles at a total cost of $38.50. This figures about 1¾ cents per mile—a most creditable showing.

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*Described in "Power," June 3, 1913.

Locomotive Smoke-Box Cinder as Fuel

SYNOPSIS—This cinder has a relatively high heat value, but, owing to the absence of volatile matter, it is difficult to ignite. Attempts have been made to burn it, mixed with coal in an ordinary furnace, but without much success. The Pluto stoker seems especially adapted to this fuel, as is shown by the test figures given.

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The utilization of cinder from the smoke boxes of locomotives is a problem which has received much thought. This cinder has a heat value of between 6300 and 8100 B.t.u. per pound, and is mostly in the form of dust particles which have been drawn through the tubes by the strong draft and though subjected to combustion in the firebox have not been fully burned, but instead only coked. The stronger the draft and the higher the grate duty, the more are such particles carried through and the less are they burned.

The comparatively high heat value of the cinder prompts the desire to use it again under stationary boilers, although efforts to this end have in the past met with little success. Through lack of the volatile element it could not be ignited readily, and its limit of usefulness was thus narrowed to adding a part of it to the usual fuel. Even then it was found that a large part of the cinder appeared in the refuse from the furnace, inasmuch as such an addition to a volatile coal did not suffice to yield a temperature high enough for ignition. Doing so with natural draft is entirely out of the question; forced draft must be used.

The first successes in this line were attained with the forced-draft, closed-ashpit type of furnace, such as the Ludlicz and Kridlo designs. These, however, have the disadvantage that the firing, cleaning and removal of clinker must be done by hand, resulting in material losses due to frequently opening the doors; especially as the fire has to be almost unceasingly worked to maintain combustion, which, even with forced draft, is poor and much of the cinder is carried off as flue dust. Furthermore, to be able at all to burn this cinder, the dust part must be sifted out, thus utilizing only the more definitely granulated remainder and necessitating special appliances.

In efforts to burn this cinder mechanically without the admixture of a high-volatile coal, arches and different grates were tried, but they were unproductive of favorable results. At the most, only about 40 per cent. of the cinder could be burned in combination with coal.

Quite recently, exhaustive tests were made, using a forced-draft "Pluto" stoker, as that furnace had already shown success in the burning of fuel relatively low in volatile content, such as coke cinder, anthracite dust and the like. The main feature of this stoker is the back-and-forth moving hollow-grate bars, which serve as air ducts, the air being blown through the slots in the upper surfaces. As this air, in its passage through the hot, hollow bars is preheated, favorable combustion results without impairment of the ignition temperature through the influx of cold air.

However, it was seen in advance that this stoker, taken as it was, could not be used for the burning of locomotive cinder. Among other things, in spite of the opposed movements of adjacent grate bars, the cinder showed a tendency to bake fast and hinder the passage of the fuel across the grate. Furthermore, this baking impeded the free egress of air from the interior of the bars to the burning fuel and as a result the cinder could not be fully consumed. Better results were ultimately obtained through slight changes, the principal improvement being brought about by the introduction of steam into the hollow grate bars. The clinker did not attach itself to the bars, the passage of the fuel across the grate was better, a more rapid rate of combustion was attained and less combustible remained unconsumed.

It was thus demonstrated that firing with locomotive cinder, unmixed with coal, is not only possible with a "Pluto" stoker, but that it can be made to yield a comparatively good efficiency. The higher temperature required for ignition is accomplished in this case by means of a fire arch which diverts the flame back toward the front of the grate; this is installed close to the grate and at an angle to it. Therefore, the course of the flame is from back to front, exerting a radiating effect on the fuel entering on the grate, thus tending to produce ignition in the initial zone of the stoker area. The following data were obtained from a test on this stoker with locomotive smokebox cinder:

RESULTS OF TEST

Duration of test, hours	3
Type of boiler	Water tube
Heating surface, square feet	1345
Grate surface, square feet	63.6
Kind of fuel	Unsifted locomotive smokebox cinder
Heat value, B.t.u., per lb	7324
Fuel fired per hour, per sq.ft. of grate surface, lb.	19.5
Water evaporated per hr., per sq.ft. of heating surface, lb.	3.45
Water evaporated per hr., per sq.ft. of heating surface, from and at 212 deg., lb	4.29
Gage pressure, lb	145
Flue-gas temperature, at boiler, deg	590
Temperature of the air for combustion	68
Draft in inches of water:	
At the furnace	0.157
At the flue	0.354
Pressure in the grate bars	0.472
CO_2, per cent	9
CO, per cent	0
C, per cent	9.5
Evaporation per lb. of fuel:	
As tested	3.77
From and at 212 deg	4.65
Heat balance, per cent.:	
Available from the boiler	63.5
Lost in waste gases	20.4
Losses through radiation, unconsumed fuel, etc.	16.1

It will be seen from the foregoing results that quite a high grate duty can be obtained from locomotive smokebox cinder if it is properly burned. The CO_2 percentage of 9 permitted the maintenance of a favorable air excess. The flue temperature was relatively high, but that was a matter of boiler construction and the heat carried off by the waste gases could thus have been materially lessened by a more suitable design. The ash was well burned out and contained only traces of combustible matter.

In considering this form of fuel the following points must be regarded: Either a chain grate is to be decided on, using a definite part of cinder in combination with coal or there must be used a furnace especially adapted to the burning of cinder only. The installation costs of a "Pluto" stoker are higher than of a chain grate, particularly as it requires forced draft.

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*Translated and abstracted from an article by O. Nerger in "Zeitschrift des Vereines Deutscher Ingenieure."

For the case in hand, let it be supposed that 20,000,000 heat units per hour are being utilized for power purposes for 300 working days of 12 hr. each. The coal will be assumed as costing $1.67 per ton of 2000 lb. at the boiler house; the price for the locomotive cinder being placed by the railway management at about $0.65. The heat value of the coal is 10,800 B.t.u., and for the cinder an average of 7660 B.t.u. is assumed and the cost determination is made for three different cases.

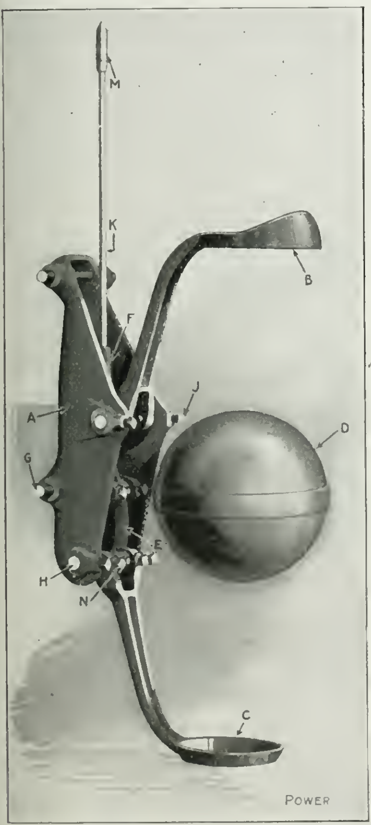


Fig. 1. Operating Mechanism of the Water Column

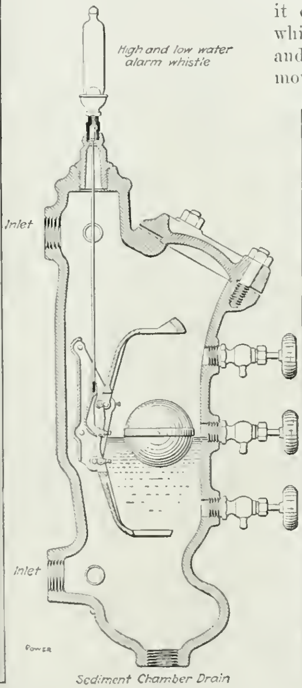


Fig. 2. Section through Water Column

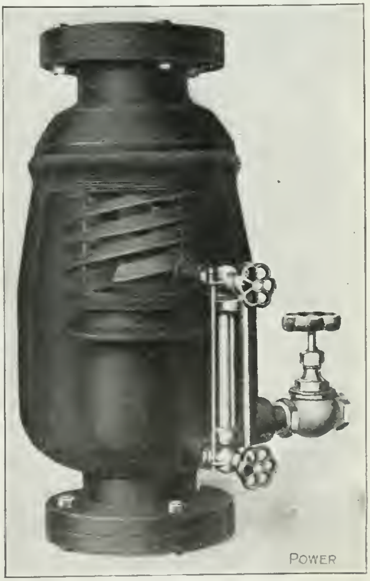


Fig. 3. Phantom View of Steam Separator

CASE 1. Chain grate, burning coal only:	
Efficiency of the boiler plant, per cent	70
Heat value of the coal, B.t.u. per lb.	10,800
Cost of fuel per ton of 2000 lb.	$1.67
Fuel required to yield 20,000,000 hourly B.t.u. $= \frac{20,000,000}{0.7 \times 10,800}$	2,465 lb.
= tons of 2000 lb.	1.3
Consequent hourly cost of fuel = 1.3 × $1.67 =	$2.17

CASE 2. Chain grate burning coal mixed with 10 per cent. of locomotive cinder:	
Efficiency of installation, per cent	65
Heat value of fuel mixture, B. t. u. per lb.	9,550
Cost of fuel mixture per ton of 2000 lb.	$1.26
Fuel required to yield 20,000,000 hourly B.t.u. $= \frac{20,000,000}{0.65 \times 9550}$	3,222 lb.
= tons of 2000 lb.	1.6
Consequent hourly cost of fuel = 1.6 × $1.26	$2.01

CASE 3. Locomotive cinder only:	
Assumed boiler efficiency per cent	60
Heat value of cinder fuel, B.t.u. per lb.	7660
Cost of cinder fuel per ton	0.65
Fuel required to yield 20,000,000 B.t.u. hourly tons	2
Hourly cost of fuel = 2 × $0.65	$1.30

Anderson Safety Water Column and Steam Separator

Fig. 1 is a good idea of the operating mechanism of the Anderson safety water column. The parts are assembled in the removable hanger frame *A* and pivoted at *H*, *G* and *J*; the pins are held in place by the setscrews *J* and *N*. The hanger frame is secured to the interior of the water column.

With high water in the boiler the float *D* rises until it comes in contact with the top lever *B*, which causes the whistle-valve rod *K* to drop and the valve to open with the downward movement of *F*. At low water, the float falls and, coming in contact with the lever *C*, opens the whistle valve, through the lever *E*.

A section view, Fig. 2, of this water column, which is made by the V. D. Anderson Co., West Ninety-sixth St., Cleveland, Ohio, shows the sediment chamber at the bottom.

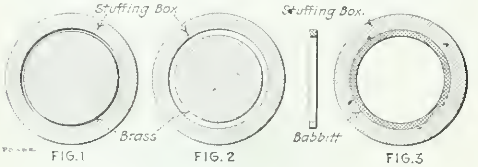
Fig. 3 is a phantom view of the vertical steam separator also made by this company. It consists of a shell, with the mouth of the outlet about midway of the body. It has a disk at the top of the same diameter as the spiral baffles, which are arranged above the outlet and around the bell-shaped deflecting piece shown.

Steam entering at the top of the separator and impinging on the baffles, is given a spiral movement and, passing around the edges of the bell center, escapes through the outlet at the bottom of the main body. All moisture separated from the steam drops from the baffles to the chamber at the bottom of the separator and is discharged through the outlet shown.

Some Pump Troubles and Their Remedies

By H. A. Gibson

A pump that had been running nicely for a long time, the valves in both the steam and the water ends being in good condition, suddenly developed a kick at the beginning of each stroke. The pump was taken down from one end to the other, in an effort to find the trouble. Then it was repacked, the setting of the steam valves was ascertained to be correct, and the water valves were carefully gone over. When the pump was again started up, however, the kick was still there.



New, Worn and Reinforced Pump Stuffing-Box

Someone suggested taking down the suction pipe; it might be obstructed, thus preventing the usual flow of water. This was done, beginning at the pump and working back toward the heater. At a point not far from the pump, where the suction pipe turned down through the floor, a wad of excelsior was found lodged in the ell. In some manner the excelsior was dislodged from the feed-water-heater filter, and although the wad was only large enough to partially obstruct the suction pipe, it could not make the turn at the ell. Its removal from the line eliminated the trouble.

The boiler-feed pumps in the same plant are of the outside-packed, plunger type. After several years' use, one of them gradually developed a tendency to stick at the beginning of each stroke and refuse to start until more steam was turned on; it was particularly troublesome when the pump was working slowly. Under this condition, with the steam throttled to produce a slow action of the pump, it became practically impossible to regulate the speed—a case of either too much speed or no action at all. The indications pointed toward troublesome packing, so the stuffing-boxes were repacked. The pump worked smoothly for a time, then the old trouble returned and things were soon as bad as ever.

An examination disclosed that, due to several years of use, the plungers were so worn that the clearance space between the bottom of the stuffing-box and the plunger was enlarged. A consideration of the drawings will show the effect on the packing of this enlarged space.

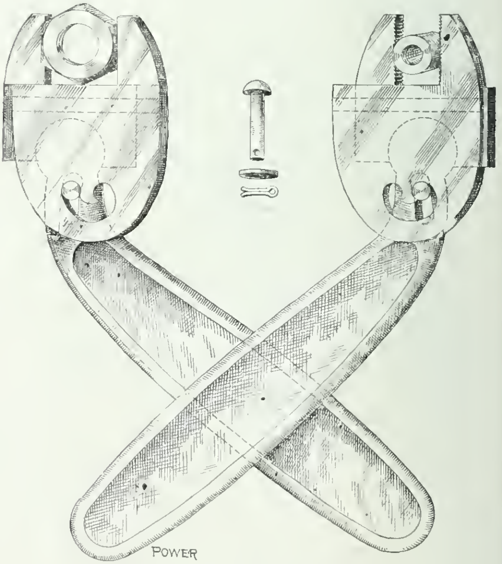
Fig. 1 represents a sectional end view of the plunger and the stuffing-box of a new pump; Fig. 2, that of the same pump after the plunger has been reduced in size by wear. In Fig. 1, the plunger clearance space is at a minimum; therefore, the edge of the packing next to the plunger has but little opportunity to become wedged in the clearance space. In Fig. 2, a different condition prevails. With the increased clearance space, there is less backing in the end of the stuffing-box for the packing. The edge of the packing next to the plunger is subject to a continual back-and-forth motion which tends to shorten its life, the packing soon breaks, and the pieces become wedged in the clearance space.

A remedy was effected by introducing babbitt rings into the stuffing-box before any packing was put in, Fig. 3. The rings were cast solid, the proper size for each box being found by measuring the outside of the plunger and the inside of the stuffing-box. It was necessary to take out the plunger to get the rings in place.

This method of treatment saved the expense of a new set of plungers and provided the equivalent of a new stuffing-box. Since the installation of the rings, the pump has given no trouble. The life of the packing has been greatly lengthened, a saving in that item and a consequent decrease in the time consumed in keeping the pump in repair.

Allan Self-Adjusting Wrench

A self-adjusting wrench which fits any size of nut within its capacity is illustrated herewith. In operation, the jaws are placed over the nut or pipe and a pull on the handle forces them to grip the object; the harder the pull, the more forceful the grip. The jaws are released by pushing the handle in the opposite direction. This wrench has an instantaneous release and does not round the corner of the nut. On account of the handle being reversible, the wrench made by A. C. Allan, 420 West Sixty-third Street, Chicago, Ill., is handy for use in close quarters.



Allen Self-Adjusting Wrench

It is made in practically three parts, the handle and two jaws. When the handle is pulled, the jaws are forced together, the pin acting as a fulcrum. A reverse movement of the handle gives an opposite movement of the jaws. The curved slot gives different adjustments.

Editorials

Business Honesty

Some think the above two words have no place together Others would take it that the first qualifies the second, like "near silk"—sort of an imitation of the genuine article. While either view might have been justified in bygone days, we mark with satisfaction the increasing frequency with which the real thing is being found in business. Old as is the precept, "Honesty is the best policy," it was wont to be quoted with mental reservations, and, like affected piety, used where it might make an impression on the ingenuous. Now, more and more, people are realizing that instead of being merely a pretty copybook maxim, it really means something. Soon, it is to be hoped, instances like the following will be too common to occasion comment:

An engineer wanted a pump to deliver against a high head, where the combination of conditions was rather peculiar. He had about decided on a certain type which he had selected from a manufacturer's catalog, but, wanting a little more data before buying, wrote the manufacturers, stating the conditions in his plant quite fully.

To his surprise, the manufacturers replied that although their pump would do the work, it was not as well adapted to it as a pump of different type manufactured by a competing company. Although their pump cost less and was smaller, it was not efficient enough for the high head required, and they therefore preferred to let the competitor have the business.

Without doubt this is the proper spirit and it is being displayed more and more by machine makers. In many instances big manufacturers are using competitors' machines themselves to perform certain work more efficiently than would be possible with their own type, for it is evident that, unless two machines are as much alike as two peas in a pod, one will have advantages over the other under conditions for which it was expressly made.

Users of power-plant machinery should realize and take advantage of this modern honesty. The manufacturers want customers to know that they are honest, but customers are prone to distrust them, because the old custom was to do almost anything to get business. Barnum, for instance, admitted it; today even the circus advertisements are mainly true.

When one wants to buy a machine for any purpose whatever, and is at all doubtful about the outcome of his selection, he need not hesitate to write to as many manufacturers as he will. Big, reliable concerns instruct their engineering correspondents to be frank. They can hardly afford to make unwarranted installations and ruin or jeopardize their names. Much less can a small concern afford to be tricky. It would have a mighty hard climb nowadays if some of its first installations were inefficient or failures. All manufacturers like to point with pride at all of their machines that are in use.

Manufacturers, as a rule, are ready to give their best advice to prospective purchasers. They employ engineers who know, and if these engineers know that the prospect is on the wrong path, they will usually guide him aright, as in the example mentioned.

It is safer to depend on the manufacturer, even though a stranger, than to rely entirely on one's own judgment.

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The Human Element in Coal Sampling

For eight or ten years many large consumers have bought coal on what the dealers call a "scientific" basis, the coal being specified to contain not less than so many heat units per pound with certain proportions of fixed carbon, volatile, ash, moisture and sulphur. This scientific method is not always indorsed with enthusiasm by the dealer, who has to be more particular when coal is bought in this way than when it is just "ordered."

It is contended, and with reason, that if the dealer is compelled to meet the specifications drawn up by the consumers, the quality furnished will be satisfactory. Undoubtedly the quality will be more uniform, but it is common experience that there is more "kicking" by the consumer, for reasons real or apparent, when "scientific" purchasing methods prevail. Often coal will meet the specifications but produce poorer results than those of other shipments which may not have been bought on specification.

When the results are unsatisfactory, the consumer usually complains more bitterly than if the same coal were not purchased on specification. To appease the buyer, the contractor orders a testing laboratory to sample and analyze the shipment. Suppose the analysis does show that the quality is as specified, then the consumer is disgruntled. The contractor sells coal, not copies of its analysis. An unsatisfied customer with a cargo of what he thinks is poor coal on his hands is not made happy by an analysis sheet.

If a coal is not satisfactory and still meets the specifications, it is manifest that the specifications are not such as they should be. Physical characteristics like the fusing point of the ash, as indexes of the behavior and value of the coal, are as good as or better than chemical analyses or calorimetric determinations. The real test is in the amount of water it will evaporate, but too many and variable factors enter into that performance for the coal dealer to accept it as a measure of the value of his product. The contract should guard the purchaser against paying coal prices for bone, slate and water, and should so regulate the relations between fixed and volatile that the character of the coal may be uniformly adapted to the provisions made by the purchaser for using it.

Many contractors contend that a sample reduced before analysis to less than a tablespoonful is not representative of a shipment of hundreds of ton. They complain that the sampling is often left to mere boys or laborers, who, as one large contractor put it, "have perhaps been out the night before, who have no commensurate conception of responsibility and who often gather a barrow load from one car or one place in the cargo and dismiss the matter with an 'Oh, that's good 'nough.'" Of course, if the sample is wrong, the most carefully made analysis is wrong.

As a fact the less one knows the better gatherer of samples is he likely to make. If he will take a scoopful from each car with his eyes shut he will get a fairer sample than a professional who would instinctively avoid or reach for certain pieces, or be influenced by appearances, which would mean nothing to the laborer and so have no effect on where he stuck his scoop.

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Welded Drums

The abstract of a paper on the determination by experiment of the stresses present in the parts of cylindrical drums, due to internal pressure, which will be found on page 90, should be of much interest to all who are concerned with autogenous welding, as well as the design of boilers and similar vessels required to withstand high internal pressures.

Welds of all kinds are open to suspicion, because there is no way yet known, without the destruction of the weld, to determine accurately whether the parts have been properly joined together. In autogenous welds, there are added factors of uncertainty, owing to the internal stresses that may be set up by local heating of the parts and the uncertainty of the quality of the metal in the weld, after having passed through the heat treatment required to make it. Apparently, the only practical way that such internal stresses can be removed is by heating the entire welded surface to a fairly high temperature after the weld is completed, and this method of treatment is impractical in the average case where autogenous welding would be used, and particularly so in that of repairs.

The work these Australian engineers are doing, to find just how the stresses are distributed in the different parts of boilers and vessels of a similar character, cannot be too highly commended. It has been common to treat problems dealing with the determination of safe pressures for boilers and similar constructions as if the manner in which the strains were brought was very simple, while in reality it is probably most complex in some cases. It was unfortunate that the drums concerned in these tests had hoops around them, for undoubtedly this construction was responsible for the peculiar results shown in one of the drums, where a portion of the surface was found to be in compression rather than in tension. The results of experiments that are to be made by these same investigators on plain drums without hoops will be awaited with interest.

The distribution of stresses in the plates of a boiler around openings, such as manholes, handholes, etc., has long been an unknown quantity in the design of such vessels. The Martens mirror extensometer would seem to furnish a ready means for obtaining the necessary data, so that reinforcements for such openings could be designed without recourse to guesswork or rules of thumb. Some of our institutions of learning are now equipped with all the necessary apparatus for carrying on this class of experiments, and practically any of the first-class boiler makers of the country would be glad to furnish the necessary specimens gratis to permit a full investigation of the subject.

We should not let our engineering friends in the Anitpodes entirely outstrip us in the matter of making such investigations, and if not, we will have to commence this work at once.

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Proper Valves and Fittings

In buying valves and fittings for power-plant service, it seems the prevailing custom to specify the sizes, types and pressures to be carried, but not to indicate what the service and general treatment will be. Further, there appears to be a tendency, probably with a view to economy, to use an article that is too cheap in the sense that it is often subjected to a higher pressure and a more severe service than that recommended by the manufacturer.

This practice frequently leads to considerable trouble, if not to actual expense, and as a consequence the manufacturer is often wrongly accused of selling an inferior class of goods.

It should be remembered that a valve or fitting is expected to withstand not only the actual pressure carried in the line, but also shocks due to water hammer, strains caused by expansion and contraction, abuse by ignorant or careless workmen and so on. Some of these cannot be foreseen, nor their extent anticipated. Some, however, although well known, are not given proper consideration. Also there are many instances where a certain valve, for example, must be opened and closed at frequent intervals, which makes the service more severe. Swing check valves especially are subjected to a hard and continuous service as well as to great and sudden shocks.

No doubt many valves and fittings are in use under higher pressure than that stipulated by the manufacturer, with no immediate bad results, but such practice is not true economy because of the early failures which are almost sure to happen. Moreover, it creates a source of apprehension and danger that is hardly worth the doubtful saving that might be considered as ensuing therefrom.

There are many uses to which the cheaper and lighter goods can be put satisfactorily, such as in suction lines, exhaust lines, etc. Also if pressures are fairly constant, piping is in good alignment, expansion and contraction are well taken care of and other conditions are favorable, it is sometimes possible to use them for pressures slightly higher than those for which they are recommended.

Such ideal conditions, however, are seldom realized; therefore, as a general rule, it is advisable to specify heavier equipment, even though it may seem unnecessarily strong. This will result in a larger margin of safety, an allowance for an increase in pressure should occasion arise at some later time, a longer life, and, consequently, fewer renewals. These advantages will more than offset any greater initial cost of installation.

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Some day it will be unusual to see steam blowing from the roofs of building and mill plants. The escape of practically a thousand heat units for every pound of steam used will eventually be considered poor engineering, except in special cases.

Correspondence

Sporadic Motor Flashing

Most high-tension linemen can cite instances of trouble due to high-tension transmission conductors being wind-swayed into contact, or near contact, with each other or with a ground wire strung upon the same towers. Such incidents are not so common on low-tension systems because the spans are not so long, as a rule there are no ground wires; the conductors are well flanked by buildings, and more or less shielded from cross winds, and the working voltage has practically no arc-striking value.

In the following instance a 500-volt, 75-hp. shunt-wound shop motor of ordinarily perfect commutation characteristics became addicted to irregular flash-overs that apparently had no explanation. It was finally noticed that the flash-overs always occurred during high winds, so the transmission span from the building entrance bushings to the line pole, 250 ft. distant, was inspected. One of the line wires was off the pole insulator and this brought the wires close together at the center of the span, so that occasionally the movements, due to the wind, would cause them to touch each other. In course of time, the insulation had become abraded so that the conductors actually made contact.

At such times the motor became, for an instant, a short-circuited generator with a resulting speed check, due to a magnetic drag. If the short persisted for more than an instant, the acting generator lost its field. In either case, the separation of the line wires and the reintroduction of voltage to the motor found it unqualified to instantly generate a counter electromotive force of appreciable value; therefore, the current would be abnormal, the field weak, and the machine would flash over.

J. A. Horton.

Schenectady, N. Y.

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Suggested Improvement for Boiler Setting

The chief object in using a boiler is to get good steaming results, and as Mr. Rockwell gets good results any criticism of the setting described on page 679 of the May 12 issue must be rather conservative, but I wish to offer a few remarks.

The shell of this boiler has about 200 sq.ft. of heating surface, and the tubes probably about 1600 sq.ft.; the latter make up the most important part of the heating surface. Complete combustion is as important as completely absorbing the available heat from the gases, and the place for scrubbing contact is in the tubes after the gases are completely burned. If the combustion chamber floor were lowered five feet at the back of the bridge wall, 100 sq.ft. would not have that scrubbing contact. Suppose that 100 sq.ft. were then only half as effective, so that the effect of 50 sq.ft. of heating surface were lost. That is about 3 per cent. of the heating surface, but the gases would be hotter than formerly when they reached the tubes and would partly offset the 3 per cent. loss. A larger combustion chamber with soft coal should easily improve combustion enough to more than offset that slight loss, especially with a heavy load. The grates being 4 ft. from the shell is good and give some space for combustion without a large chamber back of the bridge-wall. I would not expect a large gain, but think there would surely be some improvement in evaporation and less smoke if the floor of the combustion chamber back of the bridge-wall were lowered four or five feet.

Harry D. Everett.

Fort Snelling, Ariz.

⁂

Building a Smokeless Furnace

In his criticism (Power, May 26, page 747) of my article on the above subject in the issue of Apr. 21, H. Misostow intimates that the use of air ducts connecting the ashpit and the space above the grate cannot be as beneficial as stated, and calls on me to experiment to determine the course taken by the air entering above the grate as it comes through the ducts. He also states that a boiler should be adapted to the fuel it is to burn.

It is quite common practice in western New York to design furnaces under boilers with a straight bridge-wall 14 in. high and to set the boilers from 30 to 36 in. above the grates. This is because there were times when, owing to strikes, soft coal was unobtainable, and plant owners were obliged to burn anthracite in place of bituminous at any price. It is obvious that stores and industrial plants would not shut down their plants and change the furnace construction to burn hard coal when the cost is $6 per ton compared with $2.50 and $2.75 for bituminous.

As to jacketing the boiler shell with hot air with the aid of three or four ducts on each side of the furnace, this was tried with $\frac{5}{10}$ in. of draft in the ashpit, the grates blanketed and the damper partially open, before any furnace of this kind was put into service. Wads of tissue paper were placed near the intake ducts and lighted before the ashpit doors were closed, instead of using oiled waste as Mr. Misostow suggested. From these openings in front of the underside of the shell the very blanketing that I spoke of does occur.

Further evidence to prove this is presented by the following case: About two weeks ago an engineer had a mason reline one of the furnaces. From my office window I noticed quite a large volume of smoke coming from this particular stack which, since the use of the air ducts, had not smoked. The engineer informed me that the mason had closed the ducts in relining the furnace, but they were going to be opened for they were not only causing smoke, but more fuel was consumed for the same output.

The latter part of the winter two other large plants were similarly equipped. One of them uses a slight forced draft and behaves the same as the first installation referred to, and no smoke is emitted from the stack.

The other smokes slightly at the moment of most rapid distillation of the fuel, the smoke being pale gray from one minute to nearly two. The stack produces all the draft; there is no forced draft used to cause the heated air to cross beneath the shell. Air, entering the combustion chamber from the ducts, takes a course partly across the furnace and then to the rear instead of covering the underside of the shell.

F. A. Shoemaker.

Buffalo, N. Y.

* * *

Caring for the Ammonia Piston Rod

Among the trouble-making fixtures in an ice plant is the ammonia piston rod. The trouble, however, is limited or done away with when, in the first place, the best packing is used, and when the stuffing-box is packed properly. It is important that ammonia-compressor packing be regularly lubricated.

Should the rod become hot, it indicates that the packing is to tight and should be loosened, the gland lowered straight, so that it will not touch the rod on one side and scratch it. If the rod gets so hot that the packing commences to smoke, the latter will soon be ruined and the rod injured. It is best never to entirely fill the stuffing-box with packing, for one is likely to get the gland on crooked and scratch the rod.

When the frost comes back so heavy that it enters the ammonia cylinder, the rod will contract and even the best of packing will leak. Many engineers immediately tighten the gland of the stuffing-box in order to stop the odor of ammonia. In case the frost comes back that heavy (a thing which should not happen) the main liquid valve should be closed for a while, leaving the gland alone. If tightened, the rod will get hot and spoil the best of packing as soon as the frost disappears. Some engineers are too impatient to wait until the frost goes away, even when the liquid valve is closed. If the gland is tightened, one should watch the stuffing-box and loosen the gland when the frost disappears.

William L. Keil.

Philadelphia, Penn.

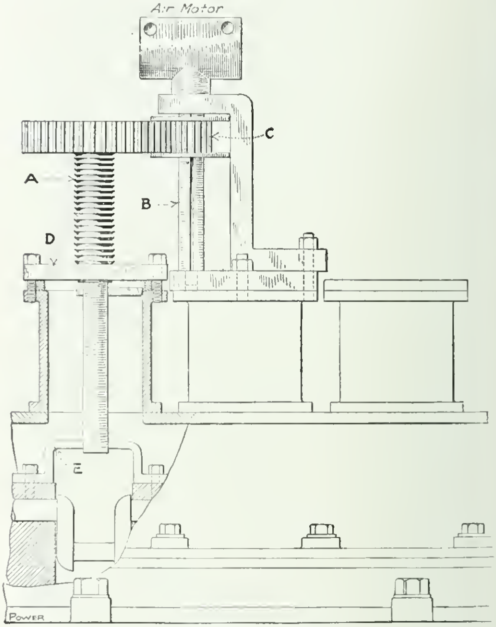
* * *

Boring Out Cylinders

The writer successfully bored out a three-cylinder, 6½-in. diameter air compressor with the rig shown herewith. The air was passing through and giving poor compression. After boring the cylinders and renewing all the pistons, which were badly worn, we are getting good efficiency. The illustration shows a side view of the boring and driving bars assembled.

The boring bar *A* had a thread which acted as a feed when revolved. The plate *D*, when drilled and tapped, was fastened down by the cylinder-head studs on top of two parallel strips, and it acted as a guide for the boring bar *A*. Driving bar *C* was supported by a brace. On the driving bar a small gear, free enough to slide up and down, acted as a drive to the main gear, which was keyed to boring bar *A*. There was a keyway the full length of the driving bar and a key which fitted in this small gear. To keep this gear from falling down and out of alignment with the main gear, two plates were riveted on its sides. The bottom guide plate *E* supporting the boring bar was fastened to the crankshaft-bearing studs.

With this rig, all that was necessary to do the job was to remove the top covers and pistons, and throw the cranks to one side to allow room for the boring bar. An air motor furnished the power for driving, and the gears used were taken from a lathe. Half-inch square steel, fastened by a setscrew, was used as a cutter.



Cylinder Boring Rig

J. M. Carter.

Vancouver, B. C., Canada.

* * *

Allowable Fine Coal in Coal Shipments

In connection with the purchase of coal on the B.t.u. basis, there is an important point that should not be neglected, namely, the allowable percentage of fine coal or slack. This, in nut and slack contracts, generally reads that the coal that can be sifted or screened through a screen having perforations one-fourth inch in diameter shall not exceed, say 30 per cent.

In preparing coal for a calorimeter test it must first be pulverized; consequently the purchaser would not be protected from too much fine coal by such a test. When much of the coal is very fine it gets through the grate and the combustible in the ash is increased greatly, although the analysis may show the coal as being of contract grade.

John F. Hurst.

Louisville, Ky.

One Way to Set an Engine

Last week one of our mechanics set a 75-hp. engine on a timber foundation for temporary use. The instruments used were a battered carpenter's level and square. When started up, as was to be expected, the engine developed several varieties of hard knocks. Upon turning it over slowly the brasses and the space between the crank disk and bearing could be seen to open and close during each revolution. The shaft was then squared and leveled by observing this opening, which effectually eliminated the pound. The engine, a double-eccentric, side-crank Buckeye, has seen 30 years' service, and deserves better treatment. Probably old age has made it somewhat philosophical.

James A. Barr.

Mt. Pleasant, Tenn.

⁂

A Quick Line-Shaft Repair

Our 3⅞-in. main line shaft broke about 4:30 p.m., shutting down more than half the machinery of the plant. The break occurred about 7 ft. from the end of the shaft. When it happened a fan engine was made to drive the shaft by coupling two shafts and only one blower was left idle out of the entire number of machines belted to this shaft. The engine, a 70-hp., high-speed unit, was terribly overloaded, and when examined later the front half of the crankpin box was broken in two and the bolts holding the straps were partially sheared. How it held together in this condition I do not know.

The plant was many miles away from a machine shop, but as soon as the coupling was disconnected the measurements were taken for a new shaft and coupling, and they were telephoned to the shop. These measurements were the outside diameter of the coupling, the depth and diameter of the socket, the diameter of the bolt circle, the number and size of the ream-fitted bolt holes, the diameter and length of the shaft, the number and size of the keyways. Special care was taken to get the measurements correct.

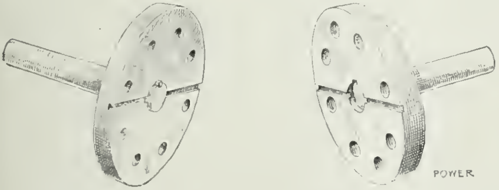


Fig. 1. Coupling with Keyway on Face

The shop worked all night on the job and delivered it for use at 11 o'clock the next morning. At 1 p.m. the main engine was shut down and the new shaft put up. The small engine was stopped long enough to uncouple and to put on two large belts, and we had the new shaft running at 5 p.m., a little over 24 hr. from the time of the break. The measurements and work were so accurate that not a single bolt hole had to be reamed, and the plug and socket portion slipped together just right.

Fig. 1 shows the halves of a coupling where the shaft extends through one half and lacks the same amount of coming flush with the face of the other half, thus forming a plug and socket, serving the same purpose as the one described. In large couplings keys are put in between the flanges to avoid the shearing strain on the bolts. The entire plant was stopped 2½ hr. in all, and a part, including the broken length, 5 hr.

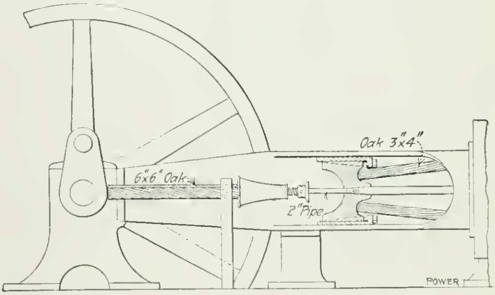
R. A. Cultra.

Cambridge, Mass.

⁂

Getting a Crosshead Off

The engineer who has never attempted to remove the piston rod from the crosshead of a large engine has an interesting piece of work before him. The sketch shows the low-pressure side of a 24x52x60-in. cross-compound Corliss engine. The piston rod was so badly scored that no packing could prevent leaking more than a few days following each packing.



Rig Set Up

It was decided that a new rod and metallic packing would be a good investment, so I set to work to remove the rod. Fig. 1 will show my method which, though not new, may help someone. A 6x6-in. oak was placed against the crank hub, supported as shown, and a 15-in. piece of extra heavy 2-in. pipe was used for an arbor.

After blocking the crosshead, a 28-in. lever was used in the jack and screwed up nearly as hard as one man could. Not a move! I struck the rod next to the crosshead with a copper hammer and it let go with a report like a gun. After replacing a new rod and metallic packing, everyone felt repaid for working on a holiday.

A. C. Waldron.

Revere, Mass.

⁂

Soda Ash in Boilers

Soda ash as a solvent has many advocates, especially where water from deep wells is used. While some claim that it will cause priming and numerous other troubles, I have found that these boilers prime because they are dirty and not enough attention is paid to blowing down while in this condition to get rid of the disintegrating scale and the concentration of salts. As the boilers become clean the necessity for frequent blowing down becomes less. In a plant using as much as 2⅜ lb. per 1000 gal. it is necessary only to blow down twice in 24 hr.

At first there is generally noticed a deposit at the caps or at any other place where there is a slight leakage; this will usually disappear as the scale is removed. The greatest foe to the successful use of soda ash is ignorance or carelessness. A variation in the treatment—the water remaining the same—will make more trouble than a uniformly low treatment. The latter will cause the formation of scale, but a high treatment one day and a low treatment the next will give rise to various troubles, such as tube burnouts, etc.

A simple way to determine the proper amount of soda ash is to take a sample of the water after treatment, and filter it into two test tubes, running about $1\frac{1}{2}$ in. into each; then onto one of the tubes put about five drops of calcium-chloride, heat the tube, and if the treatment is correct there should be noted a slight turbidity. It requires a little practice to determine the slight trace required, but a comparison of one tube with the other, with and without the calcium-chloride, will assist greatly.

JOHN F. HURST.

Louisville, Ky.

⁂

Cutting Out Mica on Commutators

To insure good commutation, it has become usual to reduce the mica at the surface of commutator bars. Practice differs somewhat as to the shape of the groove: some favor the V-shape, claiming that it eliminates the accumulation of dust or carbon, while others maintain that with this type of groove a part of the mica projects above the copper at the sides, and still prevents proper contact between the commutator and brushes. It is more general, therefore, to reduce the mica the full width of the slot to a depth of about $\frac{1}{32}$ in.

Most firms adopt this reduction of mica on all but very small machines, such as domestic or fan motors, and the practice proves justifiable if a soft brush of a graphite nature or a hard or variable quality of mica is employed. Such grooving is also successful on machines which are heavily overloaded, even if the period of overload or sparking is short, for in time the commutator bars will pit or burn to such an extent that the mica projects above the surface of the commutator.

Where soft green mica or Canadian silver amber mica is used, certain firms only groove their commutators under the special circumstances mentioned and employ annealed mica built up in sheets with a minimum of varnish or binding left in. In such cases, it is usually claimed that the mica wears down evenly with the copper, and that the mica troubles are mainly due to defective pressing and annealing of the commutator during manufacture. They regard the grooving merely as an expedient which is resorted to on large or heavy-current machines only.

J. S. FOSTER.

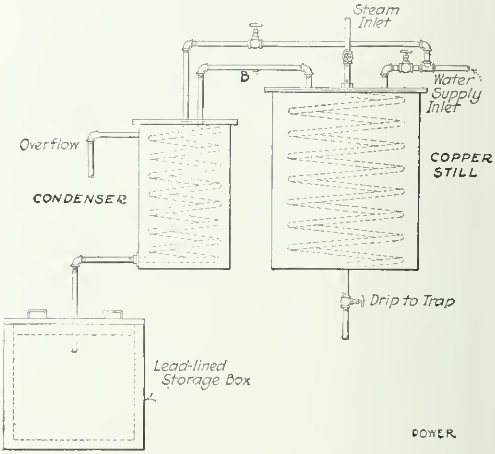
Manchester, Eng.

⁂

Distilling Water for Storage Batteries

Where storage batteries are used, it is necessary to have pure water in diluting the strong acid and for replacing that evaporated from the cells when gassing. It is often found economical to distill this water on the premises. A good outfit for this purpose is shown in the accompanying sketch.

This consists of a closed tank, or still, with a copper-pipe coil running through it, the coil being connected to a trap and drain at the bottom. City water is admitted to the space surrounding the coil until the tank is about two-thirds full. Steam is then admitted to the coil, which evaporates the water at atmospheric pressure, and the vapor passes up through the pipe *B* to the condenser, which is an open vessel containing a coil of copper pipe. City water is allowed to flow over the coil and condense the vapor, which is drained out at the bottom into a lead-lined tank, where it is kept until needed.



DISTILLING SYSTEM

The still will hold about 30 gallons of water, 20 gallons being admitted at each filling; about 3½ hours are required to evaporate and condense this amount. The storage box holds 40 gallons. Care must be taken in distilling the water, for if it is permitted to boil rapidly, it will be carried over through pipe *B* in small globules.

Water taken from iron pipe lines is likely to contain more or less iron-rust or a tincture of iron, which is injurious to the plates in the cells. Earthenware or glass jars can be used for storage tanks, but there is liability of breaking, therefore lead-lined boxes are preferable.

Some time ago, I took charge of a plant where there were two storage batteries. One was in bad condition and, wishing to save as much of the electrolyte as possible, I had a sample analyzed; it contained much iron. As all the cells were affected, this led me to suspect the tank, and upon looking into it, found part of a mason's trowel badly rusted. The carpenter had been doing some masonry work around the building and had slipped the trowel up over a piece of molding back of the tank. The fireman usually filled the battery cells, and it is supposed that he must have knocked down the trowel while the box was open, and did not notice it, or forgot to take it out of the box.

R. A. CULTRA.

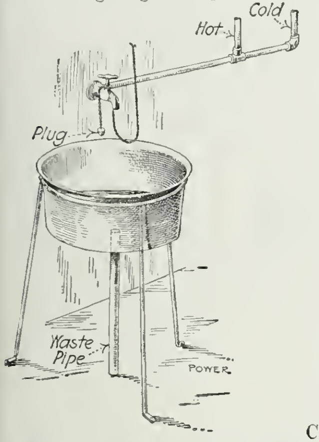
Cambridge, Mass.

⁂

Indiana Coal Production in 1913—The production of coal in Indiana in 1913 was 17,165,671 short tons, valued at $19,001,881, according to Edward W. Parker, of the United States Geological Survey. Although this was an increase of 1,879,953 short tons, or 12.3 per cent., over 1912, it fell short of the record output of 1910 by more than 1,200,000 tons.

Home-Made Sink for the Plant

A stand made, as illustrated, out of ½-in. round iron with a ring large enough to hold a good-sized enamelware pan will be found a convenience. A ¾-in. pipe, fitted with a rubber stopper, may be soldered to the bottom of the pan for a waste pipe.



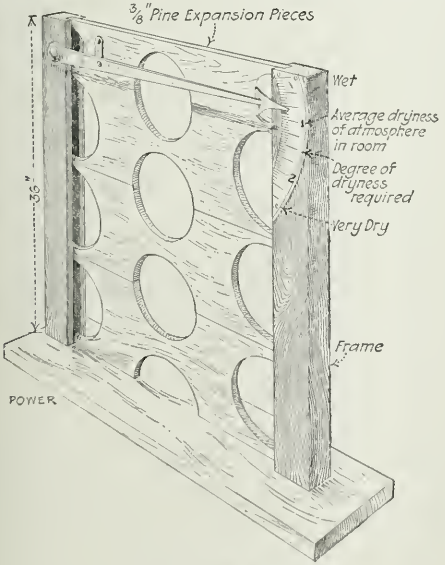
The sink is set under a hot-and-cold-water outlet and the waste pipe runs through the floor and connects with the sewer. The pan may be lifted out and the stand removed when necessary.

Charles C. Johns.

McClellandtown, Penn.

Easily-Made Hygrometer

In woodworking plants instruments called hygrometers are used to indicate the degree of dryness of the stock, or how much moisture the air contains after being passed through the drying kilns. It was the custom to put the lumber into drying rooms heated to a high temperature to extract the moisture and season the lumber, but until the hygrometer was invented the degree of dryness could not be determined. The hygrometers on the market were only suited for rooms with a temperature less than 100 deg. F., and when placed in a hot drybox it would become distorted and worthless after a few weeks.


⅜" Pine Expansion Pieces
Wet
Average dryness of atmosphere in room
Degree of dryness required
Very Dry
Frame
36"
1
2
POWER

A Drying-Room Hygrometer

The drying rooms and boxes often ran as high as 180 deg., different boxes being kept at different temperatures according to the stage of the work, and it became an item of expense to keep supplied with hygrometers. It was not a question of the room temperature, but of the dryness and the proportionate amount to increase the temperature with each degree of humidity. Soft pine will absorb moisture rapidly and it expands and contracts quickly.

An indicator was made with upright side pieces attached to a base for a frame. The inside edges of the uprights were grooved and ⅜-in. pieces of dry pine boards were shaped and put between the uprights, as shown. A pointer was attached to one of the uprights and connected by a link to the pine pieces. By comparison with a hygrometer, a scale was marked on the opposite side.

As the moisture causes the pine to swell, the pointer will rise and indicate the degree. As the air becomes dry the pine will shrink and the pointer will drop toward the bottom of the scale. By noting these changes and the temperatures at the time it is possible to keep the room at a steady degree of humidity.

This device costs less than the metal instrument on the market and will last a lifetime; the temperature of an extremely hot room will not injure it. The measurements are 36 in. high by 10 in. wide and ⅜ in. thick. It can be set on the floor or hung up, as desired, without affecting its operation. It is also useful in office rooms to indicate the relative humidity of the air.

R. A. Cultra.

Cambridge, Mass.

The Reading Habit

There is a particularly broad significance to Power's editorial under this caption in the June 9 issue. It drives home a message that we all need, even though the postscript does tend to "let us down easy" on this point. Between the lines it intimates the distinction of the reading habit and the habit of proper reading, and careful consideration shows that such difference is marked. The former, if on a hit-or-miss plan, may or may not afford substantial benefits; the latter shapes and molds a future, transforms a possibility into a reality. The spirit that actuates the habit of proper reading is the spirit that prompts the best one can do.

This term "proper reading" carries a double significance, relating to the character of matter and the manner of perusal. As to character of matter, the answer is self-evident, for every single hour given over to general and popular reading two hours should be accorded to technical literature directly, and sometimes indirectly, relating to our field. The first pays dividends in a knowledge of universal happenings and current topics; but the other pays double dividends in a wider knowledge of our world's work. To skim over the pages of this book or that technical journal aimlessly and listlessly, without any distinct concentration, is useless. The habit of proper reading is not defined in "killing time"; for this, other and more profitable ways (to one's health) may easily be found.

To read intelligently, to digest, to reflect and analyze and remember is to add notches to one's ability. Rich thoughts make the mind rich, and to concentrate the attention where richness in one's field of endeavor is afforded is taking advantage of an often overlooked opportunity. The secret of success emanates from the brain, and a well fed mind is but a forerunner of bigger things.

Notice the difference between the man who has the habit of proper reading and the one who has yet to get it. The contrast should be an inspiration to acquire the habit of careful, consistent and conscientious technical reading.

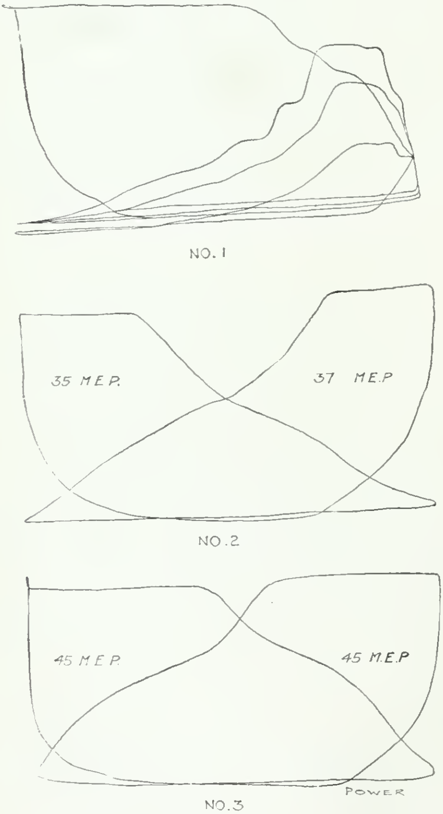
L. R. WARDE.

Newark, N. J.

*

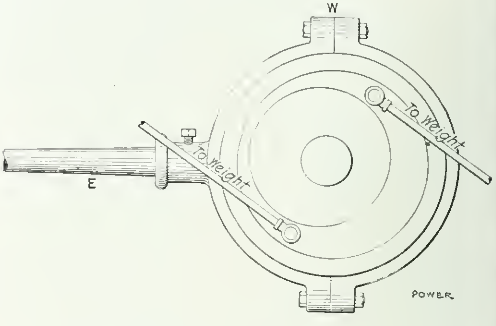
Odd Diagrams Caused by Excessive Friction

The indicator diagrams shown were taken from an automatic engine the speed of which had been cut down. The governor is of the type which has the double weights and the eccentric collar works around a fixed "boss" on the shaft.



DIAGRAMS BEFORE AND AFTER DECREASING ECCENTRIC STRAP FRICTION

This engine was noisy, it would not pull its load and its governing was unstable. By holding up with the hand at the point *E* on the eccentric rod, the engine would run quietly. The eccentric strap was drawn up too tightly, which caused the governor to produce diagrams like No. 1. By putting in a liner at the point *W* and clamping the strap up, the engine ran smoothly and produced diagrams Nos. 2 and 3 under heavy loads.



ECCENTRIC STRAP TOO TIGHT

This is another instance in which it is clear that the working parts in an automatic governor should not bind.

C. R. MCGAHEY.

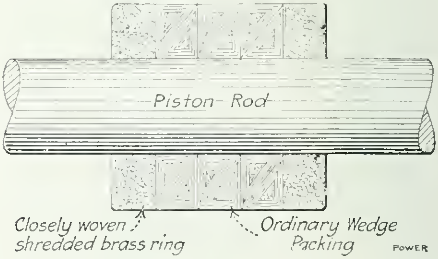
Baltimore, Md.

*

Packing a Worn Rod

Difficulty is often experienced in keeping worn piston rods packed. If the packing is drawn up tightly enough to keep the stuffing-box from leaking at mid-travel, where the greatest wear is, it will be too tight at the ends and will likely heat and ruin the packing altogether.

Having been at considerable expense from such a cause, the plan outlined in the accompanying sketch was hit upon, and it proved valuable. The capacity of the stuffing-box was five rings of packing. Two rings of finely woven, shredded brass were procured from the packing dealer. One was placed in the bottom of the stuffing-box or next to the cylinder, three rings of ordinary wedge packing were then inserted and the other brass ring put in last.



PACKINGS USED

Only slight tension is required, as the packing seems to give best service when left free to expand and contract. The brass rings at the ends perform the function of holding the packing in place and will usually last several years.

EDWARD T. BINNS.

Philadelphia, Penn.

Peculiar Engine Characteristic

A man was hired to operate a 24x48-in. Corliss condensing engine in a wire mill. All went well for a few days, then a peculiar thing happened. The new man got the engine ready to start as usual, opened up to the condenser; the vacuum was 26 in.; opened the throttle, but "nothing doing"; gave it more steam, but there was no move—looked as if that was all that could be expected to cause an engine to start. Used both starting bars and connected up again, gave her nearly full throttle. Not a move!

The time for starting was nearly up when the night man came in. He had seen the same thing happen before in this plant. He used the starting bar on the exhaust valves, giving them a sharp, quick jerk, throwing them down onto their seats—they were hung up. The engine had to start under full load; therefore the blowing through was fatal.

M. W. Carter.

Webster, Mass.

Repairs to Hoisting Engine

The illustration shows a job I had to do recently. A double 10x12-in. hoisting engine had a badly worn pinion which had to be replaced. The pinion and eccentrics were put on the shaft and the crank disks pressed on afterwards by the manufacturer. This required either the removal of one of the disks or cutting the shaft so as to remove the pinion or the eccentrics. The disks were not keyed on the shaft, but depended solely on the press fit. If a press fit has been tampered with, it does not afterward have its original strength, and even if the disk were replaced without injury after changing the pinion, the same problem would arise when similar repairs again became necessary.

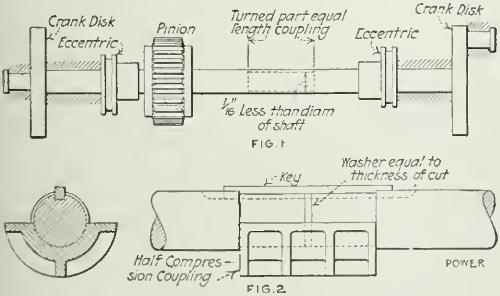

Crank Disk
Eccentric
Pinion
Turned part equal length coupling
Eccentric
Crank Disk
1/16" Less than diam of shaft
Key
Washer equal to thickness of cut
Half Compression Coupling
POWER

FIG. 1

FIG. 2

Shaft Cut to Put on New Pinion

Having decided to cut the shaft and join it again, with a compression coupling, the shaft was first turned down $\frac{1}{16}$-in. a distance equaling the length of the coupling. It was then keyseated for a key equal to the length of the coupling. The coupling was then bored and fitted accurately. The shaft was cut and a filling disk made the thickness of the cut. This, with the shoulders of the shaft, insured the exact original length of the shaft. Removing the pinion and placing the new one was a simple matter. The ends of the shaft were butted together with the filling washer between, and the compression coupling with the key in place was bolted in position. When the shaft was set up it ran perfectly true.

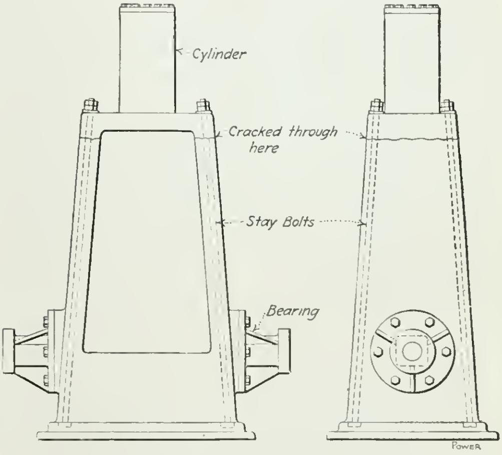
It was put into service and has been working 24 hours a day for six months at 250 r.p.m. The repair has not given a minute of trouble.

B. P. Luce.

Fajardo, Porto Rico.

Repair to a Broken Standard of a High-Speed Engine

The standard was broken off at the place shown in the sketch. As it was impossible to get a new one for some time, it had to be repaired in the following way: Four 5/8-in. bolts were put in the corners and tightened, and to prevent the head from moving sideways, iron pieces 3 in. long, 1/4 in. thick and 3/4 in. broad were fixed inside of the standard. The job turned out to be most satisfactory.



Dotted Lines Show the Position of the Bolts

J. B. Joshi.

Bombay, India.

Settling Chamber for Coke

On nearly every type of open heater employing coke as a filtering medium, a certain amount of fine coke will find its way to the feed pump and pipe to make trouble. If the water is not very bad, a good plan is to lay one sheet of about 1/8-in. perforated copper under and one over the coke, but the great danger then is running too long and getting the perforations choked up with scale and coke grit.

By far the most satisfactory type of heater is that which has a large settling and storage capacity beyond the filter. I have had success with excelsior. Charcoal (animal) also gives splendid results, but it requires too much changing and cleaning; the first cost is also much too high for ordinary use. Coke seems to hold the field, but for the past three weeks I have been experimenting with quartz. The water having an upward flow through it, the direction is reversed for a few minutes each night to wash out the dirt. So far it has given entire satisfaction.

E. R. Pearce.

Rochdale, England.

Corliss Valve-Gear Wreck

This broken valve-gear, of the single-wristplate type, had this list of broken parts: The exhaust arm on the left side and the bell crank on the right were broken off; the wristplate stud was broken at the shoulder, showing an old crack, so that only three-quarters remained good; the steam-valve stem was bent upward, making it impossible to remove it from the hood without force; the valve hood was broken off at the shoulder; the dashpot rod on the right side was so loose from the plunger that it could pulled out easily.

The loose dashpot rod was the cause of the accident, its bottom end being pulled out of the plunger; the plunger did not raise at all. Therefore, there was no cut-off on this end, and when the bell crank came down to pick up the steam arm on the next stroke, the pin holding the hook spring was still up from the previous stroke. This pin could not push the steam arm down because the rod did not go back into the plunger to its original position, and the steam arm could not be pushed down. If the flaw in the wristplate stud had not existed the dashpot rod might have been bent or the bell crank and the arm levers broken off.

This accident goes to show the minute care and attention valve-gears require.

Albert H. Israel.

New York City.

Assembling a Centrifugal Pump

In assembling the impellers of a multistage centrifugal pump, great care should be taken to get the slots or the orifices in the impellers exactly in line with the openings in the diffusion vanes. If the water strikes the vanes at an angle, it will cause a thrust sufficient to crush the metal in the thrust bearing. If the members are keyed in place, the adjusting can be done by the thrust collars.

In many instances, where the thrust bearings run hot, the trouble is due to wear permitting the shaft to work endwise, so that the impellers are thrown out of line.

John Fairfax.

Louisville, Ky.

Hospital-Plant Experience

For over three years I have been chief engineer of a hospital plant. The year previous to my taking charge of this plant the water bill was $1372; last year it was $691. We have one ten-ton refrigerating machine, and this is where I made the saving in water. The water was run over the ammonia condenser, then to the steam condenser and into the sewer; the boilers were fed from another line.

I piped the condenser water to the boiler feed heater at a cost of about $5, saving both water and coal. The coal bill the year previous was $5200, and last year it was a little less than $5000, with an advance in price of about 40 cents per ton. This was brought about partly by cleaning the boilers and the feed-water heater. The feed-water temperature was increased from 150 to 210 deg. The boilers had about four inches of loose scale

I have the satisfaction of knowing that my salary can be paid from the savings alone; I think that is pretty good. An engineer is not always hired for what he does as much as for what he knows, and if he does not stop leaks when he sees them he is not worthy the name.

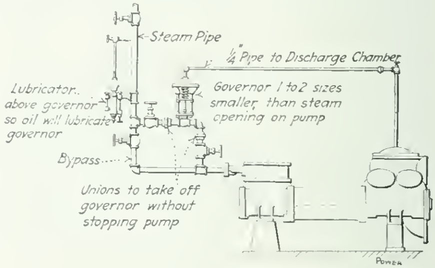
We are developing one horsepower-hour with 3.35 pounds of coal, actual test, and the engineer who has conducted a number of tests in this locality says that there are few plants doing better.

A. G. C. McKalip.

Pittsburgh, Penn.

Connection For Pump Governor and Lubricator

An automatic pump governor is often put directly in the steam line, but the proper way is to put it on a bypass, with valves and unions as shown. The governor can then be taken out to be repaired without stopping the pump. Of course, the pump will have to be regulated by hand while the governor is out. A quarter-inch pipe should be connected from the governor to the discharge chamber of the pump.


Steam Pipe
¼" Pipe to Discharge Chamber
Lubricator.. above governor so oil will lubricate governor
Governor 1 to 2 sizes smaller, than steam opening on pump
Bypass
Unions to take off governor without stopping pump
Power

Regulator Connection

A double-connection lubricator should always be placed above so that it will lubricate the governor. It will be noted also that the valves have their stems either vertical, with the handwheel above, or horizontal. If the valves are placed with their stems turned down, any leaks through the stuffing-box will burn the hand when operating the valves.

J. E. Poch

New Orleans, La.

Caution to Beginners

The beginner handling the jet type of condensing apparatus is likely to overlook an essential point—i.e., the speed of the air pump. The smaller-sized outfits have but one pump performing the combined function of an air and water pump. The water flows to the pump and the only check as to its amount is the opening of the inlet or injection valve (not the speed of the pump). Consequently, if the pump is not operating fast enough, there is a chance of flooding. The operator must see that the pump is constantly operating with a distinct jump at each end of the stroke, which indicates that the pump is running ahead of the water.

H. F. Johns.

Louisville, Ky.

Inquiries of General Interest

Solving Proportion by Slide Rule—In the proportion 6 : 14 : : 30 : x how is the value of x found on a slide rule?

C. G. T.

Set the slide so that the division 6 of the slide comes opposite 1.4 on the scale, then the division 3.0 standing for 30 on the slide will be opposite 7.0 standing for 70, the value of x.

Dry Saturated Steam—What is meant by dry saturated steam?

T. H.

Steam that is at the evaporative temperature corresponding to its pressure and which contains no water held in mechanical suspension, i.e., it is steam which is neither wet nor superheated.

Relative Evaporation with Iron and Copper Tubes—What is the relative evaporative capacity of fire-tube boilers fitted with iron or copper tubes?

A. J.

Tests of two boilers made exactly alike except that one had iron fire tubes and the other copper fire tubes showed that their evaporative activity was practically the same.

Effect of Oil on Concrete—What effect has oil on cement concrete?

C. S. T.

Mineral oil has no appreciable effect on the strength of concrete, but animal and vegetable oils have a tendency to disintegrate concrete by the solvent action of acids which they liberate upon decomposing.

Greatest Pitch Taken as Unit Length—In figuring the strength of butt and double-strap joints, why are the calculations based on the pitch of rivets of a row having the greatest pitch?

M. D.

Any other unit of length of joint might be employed, but the computations are simplified by assuming the greatest pitch as the unit.

?

Advantages of Superheated Steam—What is the advantage of using superheated steam expansively in an engine?

G. B.

The chief advantage from using superheated steam is the prevention of initial condensation. The higher the degree of superheat the drier the steam at cutoff, and with the degree of superheat high enough, cylinder condensation may be entirely prevented.

To Find the Length of Belting in a Roll—How can the length of a belt be found from measurement of the roll and number of turns made by the belt?

R. G.

Add together the diameters of the roll and of the eye both measured in inches, and multiply the sum by the number of turns. This product multiplied by 0.1309 will give the length of the belt in feet.

Clearance—What is the difference between engine clearance and piston clearance?

G. B.

Engine clearance is the volume included between the piston, when at the end of its stroke, and the seats of the valve at the same end of the cylinder. Piston clearance is the distance the piston would have to travel beyond the end of its stroke to strike the cylinder head.

Weight of Water at Temperature of Steam at 100-Lb. Boiler Pressure—What is the weight per cubic foot of water in a boiler when the water is at the temperature for generating steam at 100 lb. per sq.in. boiler pressure?

S. T.

To generate steam at 100-lb. boiler pressure or 114.7 lb. absolute, the water would be at a temperature of 337.9 deg. F., and at that temperature it weighs 56.02 lb. per cu.ft.

Evaporation from and at 212 Deg. F.—In considering the performance of a boiler what is meant by equivalent evaporation "from and at 212 deg. F."?

G. R.

The evaporation that would have resulted from the transfer of the same amount of heat when the feed water is supplied at 212 deg. F. and the steam is generated at a pressure equal to the normal atmospheric pressure, or 14.7 lb. absolute. Under these conditions the steam would be generated "at" 212 deg. F. "from" water at 212 deg. F.

Difference of Expansion in Vertical Boiler—What would cause inequality in expansion of the outside sheets and tubes of a vertical fire-tube boiler?

E. M. S.

From coatings of nonconducting materials on the inside of the boiler the outside sheets would be at a lower temperature and the tubes would be at a higher temperature than that of the water and steam, and there would be a difference in expansion due to the difference of temperatures of the materials. There is also a difference in expansion of the shell and of the tubes due to difference in structure of the materials.

Cushion Valves on Duplex Pump—What is the purpose of cushion valves on a duplex pump?

J. P.

When the piston in the steam cylinder passes over the inner or exhaust ports no further exhaust steam can escape and without cushion valves, whatever steam then remains in the cylinder acts like a cushion by being compressed between the piston and cylinder head. This compression may be excessive and by means of cushion valves, which connect the outer or steam ports and passages of the cylinder with the inner or exhaust passages, the amount of compression can be reduced by permitting the escape of more or less of the compressed steam into the exhaust passage by way of the steam passage.

Use of Steam Siphon with Compressed Air—Why will not a steam siphon raise water when operated by compressed air?

J. M. D.

Because the form of the siphon is not adapted to the use of compressed air. A steam siphon operates by condensation of steam within the steam tube and by continuation of the velocity of the steam as condensate. After leaving the tube the air and water ahead of the tube are driven forward to the discharge outlet of the siphon accompanied by a relief of pressure from the suction chamber. When compressed air is used it has a tendency to expand upon leaving the tube and unless the tube and surrounding spaces are sufficiently favorable to concentration of the energy of the air beyond the water outlet, expansion of the air causes back pressure in the suction chamber, which hinders siphonage in the same manner as when the suction chamber is filled with uncondensed steam.

Force Required to Stop a Body—In what time and space will a weight of 640 tons moving at a velocity of 44 ft. per sec. be brought to rest by a resistance of one ton?

W. R. B.

The acceleration of gravity is 32.16 ft. per sec., and the force of gravity acting on a mass weighing 640 tons will bear the same relation to the acceleration of gravity as the resistance one ton bears to the acceleration or retardation which is created; i.e., calling the retardation x,

$$640 : 32.16 : : 1 : x, \text{ or } x = 0.05 \text{ ft. per sec.}$$

As time = velocity ÷ acceleration, the time required for bringing the mass to rest would be

$$\frac{44}{0.05} = 880 \text{ sec., or 11 min. 40 sec.}$$

and as the space covered would be ½ the initial velocity × time, the space required would be

$$\tfrac{1}{2} \times 44 \times 880 = 19{,}360 \text{ ft.,}$$

or

$$\frac{19{,}360}{5280} = 3\tfrac{2}{3} \text{ miles.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XVIII

Last Lesson's Answers

76. From equation (33)

$$a = \frac{V^2}{2S}$$

where a = The desired acceleration;
V = The velocity, 44 ft. per sec.; and
S = The space, 800 ft.

Hence, $a = \frac{44 \times 44}{2 \times 800} = 1.21$ *ft. per sec. per sec.*

77. From equation (40)
$V_1^2 = U^2 - 2aS$, or $2aS = U^2 - V_1^2$
where U = 66 ft. per second;
V = 22 ft. per second; and
S = 1000 ft.
Therefore,

$$a = \frac{U^2 - V^2}{2S} = \frac{66^2 - 22^2}{2 \times 1000} = 1.936 \textit{ ft. per sec. per sec.}$$

78. An acceleration of 2 ft. per sec. per sec. means that for every second the body is in motion the increase or gain in velocity is 2 ft. per sec. Then the gain in velocity in feet per minute for every second the body is in motion would equal 60 × 2 or 120 ft. per min. per sec., which is to say that at the end of one minute the body would be moving with a velocity of 120 ft. per sec. Likewise the gain in velocity in feet per hour would equal 120 × 60 or 7200 ft. per hour per sec. Since there are 5280 ft. in a mile, 7200 ft. will equal $\frac{7200}{5280} = 1.36$ miles. Hence an acceleration of 2 ft. per sec. per sec. is equivalent to an acceleration of 1.36 miles per hour per sec. Now if the velocity is increasing at the rate of 1.36 miles per hour for every second the body is in motion, then for every hour the body is in motion the gain in velocity would be 3600 × 1.36 = 4896 miles per hour. Therefore, an acceleration of 2 ft. per sec. per sec. is equivalent to an acceleration of 1896 miles per hour per hour. This shows that the value of a given acceleration varies directly as the square of the factor changing the unit of time, and inversely as the factor changing the unit of length.

79. From equation (39)

$$V_1 = U - aT \text{ or } a = \frac{U - V_1}{T}$$

In this problem
U = 88 ft. per sec.;
V_1 = 22 ft. per sec.;
T = 20 sec.
Hence,

$$a = \frac{88 - 22}{20} = \frac{66}{20} = 3.3 \textit{ ft. per sec. per sec.}$$

80. From equation (40)

$$V_1^2 = U^2 - 2aS \text{ or } S = \frac{U^2 - V_1^2}{2a} = \frac{88^2 - 22^2}{2 \times 3.3}$$
$$= 1100 \textit{ ft.}$$

Uniform and Accelerated Motion (Continued)

Space may be represented graphically by an area, just as the work done in an engine cylinder is proportional to the area of the indicator diagram. It has previously been shown that the space traversed by a body is the product of the average velocity times the time; therefore, for an area to represent space, the base of the figure must represent time and the altitude of the figure represent the velocity of the body.

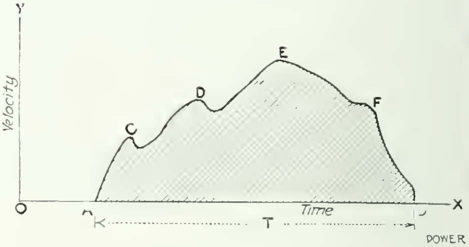


Fig. 64.

Thus, in Fig. 64, let the distances measured parallel to the axis OX be proportional to the time, and the distances measured parallel to the axis OY be proportional to the velocity of the body. Now suppose a body moves for an interval of time indicated by the line AB and during this time the velocity varies as shown by the irregular line $ACDEFB$, then the space passed over by the body will be given by the area $ACDEFBA$, for this area is equal to the product of the base AB (which corresponds to a certain interval of time) and the altitude which is the average height of the figure and represents the average velocity. In a case like this the average velocity can be obtained by dividing the figure by vertical lines into 10 or 20 smaller areas, measuring the mean height of each and finding the average height of them all.

A graphical representation affords an easy method for becoming familiar with the formulas for uniform and accelerated motion. In Fig. 65 let the line AB represent a given interval of time of T sec.; let the line AC be the initial velocity U of the body in feet per second; and the line BE give the final velocity V_1 of the body. Draw the line CD parallel to AB. Evidently the line DE will be the gain in velocity during the interval of T seconds, since the line $DB = AC = U$. But this gain in velocity is equal to the acceleration times the time or aT. The figure, then, shows at a glance that the final velocity V_1 is equal to the initial velocity U plus the gain in velocity which is aT, or

$$V_1 = U + aT$$

which is the same as equation (35).

If the body is moving with a uniform velocity, only the space traversed in T sec. will be equal to the area $ACDBA$ or UT. Likewise if the body starts with an initial velocity of U ft. per sec. and moves for T sec. with an acceleration of a ft. per sec. per sec., then the space passed over will be given by the area $ACEBA$, which may be divided into the two areas $ACDBA$ and $CDEC$.

$$\text{area } CDEC = aT \times \tfrac{1}{2}T = \tfrac{1}{2}aT^2.$$

(The area of a triangle equals the product of one-half the base times the altitude); and the area $ACDBA$ equals UT. Hence

$$\text{area } ACEBA = UT + \tfrac{1}{2}aT^2$$

or the space passed over is the same as by equation (34).

Again, if the body is moving with a deceleration in addition to its initial velocity, then the space traversed will be given by the area $ACFBA$, where the line DF equals the loss in velocity or aT (of course, in this case a is the deceleration in feet per second per second). But

$$\text{area } ACFBA = \text{area } ACDBA - \text{area } CDFC$$
$$= UT - \tfrac{1}{2}aT^2$$

which is the same as given by equation (38).

FALLING BODIES

Gravity attracts all bodies toward the earth with an acceleration which varies with the location of the body relative to the center of the earth. This acceleration is the same on all bodies, independent of their size, shape or weight. If a feather and a lead ball were put in a vessel from which all the air had been removed, it would be found that both objects would fall at the same rate. However, if the ball and the feather were dropped from the top of a building it is evident that the ball would reach the ground long before the feather, simply because the resistance of the air acts as a retarding force on the feather to a greater extent than it does on the ball. Further, if a body falls under the action of gravity alone, the velocity of the body will increase at a uniform rate. The acceleration, due to gravity, may be determined experimentally by the use of the Atwood machine, which will be described in a later lesson. For all practical purposes, the value of this acceleration may be taken as 32.16 ft. per sec. per sec., and throughout the remaining lessons the letter g will be used to denote the *acceleration due to gravity.*

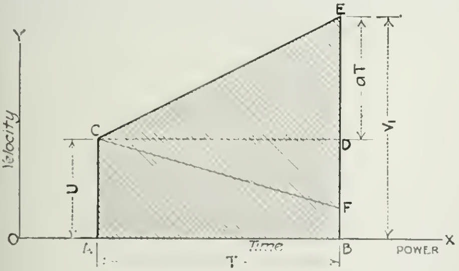


FIG. 65.

If a body be dropped from the top of a tower, the velocity will increase at the rate of g ft. per sec. for every second the body is falling, thus at the end of the first second the velocity will be 32.16 ft. per sec., at the end of the second second it will equal 2 × 32.16, or 64.32 ft. per sec., or, in general, *if an object starts from rest and falls under the action of gravity, the velocity at the end of T_1 sec. will be gT_1 ft. per sec.*

Let V = the final velocity in feet per second. Then,

$$V = gT_1 \qquad (41)$$

The average velocity will be the sum of the initial and final velocities divided by 2 or

$$\frac{0 + gT_1}{2} \text{ or } \tfrac{1}{2}\,gT_1$$

and the distance the body has fallen in the given interval of time will equal

$$\tfrac{1}{2}gT_1 \times T_1 \text{ or } \tfrac{1}{2}\,gT_1^2.$$

Let H equal the vertical distance the body has fallen. Then,

$$H = \tfrac{1}{2}\,gT_1^2 \qquad (42)$$

But, from equation (41)

$$T_1 = \frac{V}{g}$$

Substitute this value of T_1 in equation (42) and there results

$$H = \tfrac{1}{2}\,g \times \frac{V^2}{g^2} = \frac{V^2}{2\,g}$$

or

$$V_2 = 2\,gH \qquad (43)$$

Problem—A wrench is let fall from the top of an elevator shaft which is 200 ft. deep. What is the velocity of the wrench when it reaches the bottom of the shaft? How long did it take the wrench to fall?

Solution—To find the velocity substitute the value of H, which in this case is 200 ft., in equation (43) thus,

$$V^2 = 2\,gH = 2 \times 32.16 \times 200 = 12{,}864$$

or

$$V = 113.4 \textit{ ft. per sec.}$$

The time of flight may be found from equation (41), where $V = 113.4$ and $g = 32.16$, hence

$$T_1 = \frac{V}{g} = \frac{113.4}{32.16} = 3.5 \textit{ sec.}$$

Assume a body projected vertically upward with an initial velocity of U ft. per sec. Then neglecting the friction of the air, if it were not for gravity the body would continue to move up with a velocity of U ft. per sec. However, the instant the body starts upward gravity exerts a deceleration of g ft. per sec. until the body is finally brought to rest at a certain height above the ground. The time that will elapse before the body comes to rest may be found by the use of equation (39) in which case $V_1 = 0$, $a = g$, $T = T_1$. Hence

$$0 = U - gT_1 \text{ or } U = gT_1$$

and,

$$T_1 = \frac{U}{g} \qquad (44)$$

The instant the velocity becomes zero, the body will immediately start to fall with an acceleration of g ft. per sec. and at the end of a certain time will reach the ground with a velocity equal to that with which the body was projected upward.

STUDY QUESTIONS

81. Does the acceleration due to gravity increase or decrease with the distance of the body from the center of the earth?

82. An object dropped from the top of a steel stack, takes 4 sec. to reach the ground. Find the height of the stack.

83. A ball is thrown vertically upward with a velocity of 84 ft. per sec. When will the ball's velocity become zero?

84. In problem 82 how far was the object from the ground at the end of the second second?

85. A standpipe 50 ft. high is filled with water. With what velocity will the water leave a nozzle at the base of the standpipe? (Assume all the head converted into velocity.)

⁂

Correction—In Elementary Mechanics—III, Apr. 7, 1914, the answers to problems 8 and 9 should have been 1276 lb. in both cases, instead of as given.

Heating Engineers Meet at Cleveland

The semi-annual meeting of the American Society of Heating and Ventilating Engineers, held at the Hollenden Hotel, Cleveland, Ohio, on July 9, 10 and 11, was well attended.

The first session was called to order by President Samuel R. Lewis, who complimented the members on their promptness in attendance and in behalf of the society thanked those who had furnished papers early enough for the secretary to send copies to the members in advance of the meeting; in so doing, authors of papers promote the welfare of the society by stimulating interest in the meetings, encourage the attendance of members and render material assistance to the officers and members in conducting the proceedings.

The first paper was by the president, in the form of an address on "The Importance of Proper Perspective," in which he stated that one of the limitations of the human mind is its normal inability to become sufficiently detached to view things in their proper perspective. After taking the utmost care in refining some detail of a process, we operate for years in combining such refinement with redundant, unconsidered rules-of-thumb. We are prone to follow precedent at the expense of progress. Too often we fail to view a clear perspective.

The most elaborate computations will be made, for instance, of heat losses, pipe sizes and radiator surfaces, affecting possibly one-third of the cost of an installation, and then we find that the designer guessed at the chimney size or type or height, took an incompetent manufacturer's rating on a boiler, or rendered abortive his own detailed computations by assuming that the manufacturer's competitive guess as to the capacity and efficiency of his particular apparatus was correct.

There are many questions in heating and ventilation demanding a better perspective. We refine the artificial heating plant, spend time, dollars, skill and genius in elaborating the heat-transmitting appliances and the fuel-consuming devices, with no more than a cursory investigation of the type of construction of the building, and with no effort to influence its construction so as to reduce the heat losses.

There are instances where 5 per cent. of the cost of the building, expended on heat transmission insulation rather than on a larger heating plant, saved, in fuel charges alone, its cost within three years. This is a field which is almost unexplored. We know, however, that an ordinary sawdust-packed icehouse with respect to heat insulation is much more efficient than an ordinary dwelling, and how much longer heat is retained in an ordinary fireless cooker than in the best insulated transmission equipment of an ordinary heating plant.

We know that poor insulation of walls and windows is the greatest enemy of good ventilation, preventing proper diffusion of the fresh air; that tight windows or storm sash permit of considerable fuel savings, and that warm winter buildings are cool summer buildings, but we seem unable to get enough perspective to use this knowledge. Buildings with rattling windows and no storm sash, thin walls, cold attics and cellars, direct-indirect radiators, unduly high ceilings, single slab roofs, etc., coupled with the most elaborate and expensive heating plants, should cease to exist.

In our practice as engineers, are we losing perspective in regard to the location in the room of the heat source? Heat transmission varies, among other things, in a certain proportion as the difference in temperature between the hot and cold objects varies. Is it, then, the best practice to place the hottest thing in a room against the coldest object? With reasonably tight windows and fairly well insulated walls, the radiator may be alongside the inside wall as satisfactorily as alongside the outside wall. May not the radiator be smaller, will not the piping be less expensive, will not the fuel cost be low, if this procedure is carried out consistently?

Is it not a loss of perspective to cling to the idea that air for ventilation shall all have been heated prior to its entry to a room? Our belief in this is traditional. Is it based on truth? It has been demonstrated that unheated air, when introduced into rooms under certain conditions, feels better than air which has been heated. This process has proven good for street cars. Shall we not hope for the development of the process for buildings, so perfected that it shall operate continuously and effectively? It will surely follow the construction of properly insulated buildings.

Is our perspective normal as affecting air-cleaning apparatus? Are there no natural processes from which we may take a hint aside from the reduction of atmospheric dust by rain? Will not our progress accelerate when moisture content and dirt removal from air are seen clearly as separate processes? Is it impossible to bring forth an air cleaner which shall operate continuously, economically and efficiently at less original and maintenance cost than the modern commercial air washer, and thus become more popular by doing for our homes, at least approximately, what our nasal functions do for our lungs so much more efficiently than any of our artificial cleaners? By the inspiration of contact, the members of the society gain a clearer perspective of the problems of their profession, and with that clearer perspective there is greater alertness in grasping elements of success.

A discussion commendatory of the paper followed its reading, and the remainder of the first session was taken up by reports of special committees and the reports of the committees on "Heat Transmission of Direct Radiators," by J. A. Donnelly, chairman; "Reducing Fire Risks in Blower System," by A. M. Feldman, chairman; "Standardizing a Method of Testing Air Washers," by A. E. Stacy, Jr., chairman. No action was taken on the report of the committee on "Coöperation with Other Societies on Adopting a Standard for Flanges," C. R. Bradbury, chairman.

The report of the special committee on "Coöperation with Educational Committee of National District Heating Association" was referred to the publication committee for the council to pass upon.

The second session was held during the afternoon, and was occupied by the reading and discussion of many topics of professional interest. Through the courtesy of President Lewis, this session was presided over by Prof. John R. Allen, M. E., of the University of Michigan, past-president of the society. The first business was the reception of the report of the special committee on "Model Compulsory Ventilation Law," by J. D. Hoffman, chairman. There was an interesting discussion of the committee's report by Messrs. Weinshank, Chapman and others, and the discussion was clarified by the lucid guidance of Prof. Allen.

D. L. Cooke presented a paper on car ventilation, which showed surprising thoroughness with which systems of ventilation had been devised for passenger cars and how difficulties had been overcome. Descriptions were given of successful applications of the most approved principles of ventilation. Discussion of this paper was taken up along with that on "Electric Car Heating and Temperature Control," by W. S. Hammond, nonmember and vice-president of the Consolidated Car Heating Co., which was read by the secretary. This paper presented many interesting facts and statistics on car heating, showing the advantages of electric heating service for cars and fallacies of arguments that have been advanced as to the extravagance of this system of car heating.

Among other data of interest, it was stated that steel cars require at least 30 per cent. more heat than wooden cars having the same capacity, and that the number of people in a car perceptibly affects the amount of heat required, tests seeming to show that the body of a man gives out about twice as much heat as that of a woman, the records showing a variation from 198 B.t.u. to 400 B.t.u. per individual, varying with external temperature and character of clothing worn. Therefore, when 10,000 B.t.u. per hour are required for maintaining proper temperature of a car, at the rate of 200 B.t.u. per person per hour, the car would be sufficiently heated by the presence of 50 persons. The practical bearing of this is that if heat is supplied at a uniform rate it would result in overheating during the periods of heavy traffic.

By automatically controlled electric heating a comfortable degree of heat can be maintained, and at the same time it allows the use of the extra power for propelling cars at times when travel is the heaviest. The paper also calls attention to the fact that it would be but fair for a company considering the advisability of employing electricity for car heating to consider, not the proportionate cost of current consumed, but rather to charge against the heating system only the cost of additional current.

A paper on "Radiation Needed for Exposed Kitchens when Gas Is Used for Fuel" was presented by J. A. Donnelly, and one on "Natural Gas Heaters" was read by O. J. Heunhold. The discussion of these was merged with the special topics for discussion on "The Economy of Heating by Natural

Gas" and "To What Extent Can We Economically Use Manufactured Gas for Heating?"

A discussional letter bearing on the use of manufactured gas, from R. P. Bolton, was read by the secretary, in which Mr. Bolton stated that from data which he had collected in relation to the cost of coal for heating at a typical New York City heating plant during those months of the heating season which require but little heat, he was persuaded that there should be a very decided saving by the use of manufactured gas as fuel at such times.

George S. Burrows, nonmember, of the United Gas Improvement Co., of Philadelphia, being present, was called upon for information on the subject of the use of manufactured gas for heating purposes. The speaker showed that he had been extensively engaged in encouraging and extending the use of manufactured gas with special regard to warming buildings, and could hardly state that 80-cent gas could compete with $6 coal for warming by the best appliances developed to the present time. There is, however, a broad field in the use of manufactured gas where the saving of labor, cleanliness and convenience are of greater consideration than the first cost of fuel, but before manufactured gas can successfully compete in cost with the grades of coal ordinarily employed for heating buildings, there will have to be radical changes in relative cost, and sweeping improvements in methods of burning gas in steam, hot water and other types of heating apparatus.

struction of odors which accompany noxious exhalations might not be beneficial physically through psychological influence.

The concluding professional session was convened on the morning of July 11, the first paper being presented by Norman A. Hill on "The Heating Industry in Canada," in which the author touched upon the peculiarities of Canadian trade practice, and practices in steam vapors and hot-water heating, and the absence of air conditioning, together with comments on contract practices and opportunities for manufacturers of ventilating and heating apparatus.

R. P. Bolton read a paper on "Hydro-Electric Power Compared with Steam," claiming that the burden carried in development of water powers was not generally warranted in competition with the cost of developing power by steam, and that the problem of coal conservation is rightfully within the province of those branches of engineering which are devoted to the economical development of heat. The only other paper read was presented by Secretary J. J. Blackmore, on "Our Society, Its Aims and Opportunities," which was replete in words of enthusiasm and encouragement.

Before adjournment, President Lewis took occasion to congratulate the members on the success of the meeting, which he said was largely due to the perfect arrangements and untiring efforts of the reception committee, Messrs. J. H. Bacon, Jr., W. H. Kingsbury, R. S. Mayer, F. G. Phegley and F. H. Valentine.

GROUP OF MEMBERS AND GUESTS AT SEMI-ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, CLEVELAND, OHIO, JULY 9-11, 1914

A discussion on the employment of natural gas for heating purposes, in which many of the members participated, revealed the consensus of opinion that natural gas could not be satisfactorily employed as fuel for heating apparatus, unless in specially designed furnaces, and that the requisites of coal-burning furnaces of designs usually given to heating apparatus make their employment for gas burning awkward and inefficient. From the testimony of members present from various sections where natural gas is available, the experience has been quite uniform that, in consequence of the increase in price and shortage of supply during colder portions of the heating season, consumers have generally had to fall back on coal as a fuel during the coldest part of the heating season. For that reason, and to cover uncertainties in the supply, heating apparatus suitable to coal burning is generally regarded as indispensable, and in view of the inadaptability of the usual coal furnace designs to gaseous fuel, natural gas can rarely be employed alternately or in combination with solid fuel without providing a special furnace for each, the usual method being to employ a gas heater connected to the ordinary forms of coal-burning boilers.

The third professional session was held on the morning of July 10. "Reduction or Elimination of Noise in Mechanical Ventilating Apparatus" was the subject of a paper presented by R. W. Pryor, Jr. A paper having for its subject "Ozone and Ventilation," by M. W. Franklin, brought out a spirited discussion on the efficacy of artificially produced ozone, whether its presence afforded more than a mask for offensive odors and whether in ventilation the actual de-

The president's expressions of appreciation were warmly seconded by remarks of several members, and after tendering the reception committee a vote of thanks for their successful labors the meeting was declared adjourned.

EXCURSIONS AND ENTERTAINMENTS

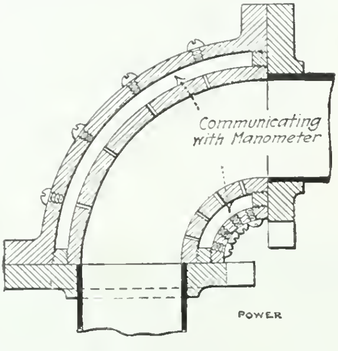
On the afternoon of Friday the members, ladies and guests of the society made a visit of inspection to the laboratories of the National Lamp Works of the General Electric Co. at Nela Park, where they were agreeably entertained and instructed by an illustrated lecture on "Effects of Direction and Distribution of Light," by Dr. M. Luckiesh, of the Physical Laboratory of the National Electric Lamp Association. The party was then conducted to the instruction and recreation camp of the company, where, under the courteous guidance of L. H. Britton, manager of sales department, and his assistants, inspection was made of the lamp company's complete and extensive provision for entertaining delegations of its employees and instructing them in the technical and commercial branches of electrical illumination. After partaking of refreshments furnished by their hosts, the party returned to the Hollenden with impressions of a delightful half day's outing.

Other entertainment provided by the reception committee consisted of automobile trips for the ladies, a musicale and refreshments in the assembly room of the Hollenden on Thursday evening, group shopping tours for the ladies, a banquet at the Hollenden on Friday evening, and on Saturday an automobile trip for the ladies to Euclid Park and return.

Flow Metering Apparatus

At the recent meeting of the American Society of Mechanical Engineers, A. M. Levin described an apparatus for measuring the flow of steam or other fluids in closed channels. Instead of determining the velocity of the fluid from its inertia pressure, as in the pitot tube and the venturi meter, the centrifugal pressure is measured as the fluid passes through an elbow. This elbow, as shown in the cross-section, is provided with suitable pressure ports through which the pressures may be transmitted to an ordinary U-tube manometer.

The formulas relating to this flow-bend are of the same form as those applying to the pitot tube, except that there is prefixed a multiplier which depends on the ratio of the diameter or width of the channel to the mean radius of curvature of the bend. Where the density of the fluid remains constant, the expression for the velocity is



Metering Bend

$$V_m = \sqrt{\frac{p}{2D}} \times \sqrt{2gH}$$

V_m Mean linear velocity:
p = Mean radius bend;
D = Diameter of pipe or width of channel;
g = 32.16;
H = Difference in pressure at outer and inner walls of bend as measured by the manometer and expressed in feet head of the fluid.

The second term of the expression ($\sqrt{2gH}$) is that ordinarily applying to the pitot tube.

⁂

Notes on Operating High-Tension Transmission System

The report of the "Engineering Data Committee," recently submitted at the Detroit convention of the A. I. E. E., contains much valuable information relative to the practices of power companies supplying high-tension transmission systems. The material is compiled from the replies of twenty-five companies each transmitting at 25,000 volts or over.

Neglecting much of that part of the report dealing with construction features, some of the questions and answers relating more particularly to the operating practices are in abstract as follows:

Of the twenty-five systems, only two are exclusively hydro-electric, one exclusively steam and the remainder combination.

Seventeen companies employ a grounded neutral, most of them, however, through little or no resistance.

Electrolytic lightning arresters are employed by sixteen companies; three use the horn gap; one both horn gap and electrolytic and two multigap and electrolytic. One small system in California transmitting at 60,000 volts, does not use any lighting arresters at all. Twelve charge the electrolytic arresters daily, one twice a day, and three twice a day in winter and three times in summer. The majority charge through no resistance.

To open a short-circuit on the line, which holds on, the general practice seems to be to reduce the voltage of the generators. One company, however, separates the system into sections and cuts out the step-up transformers on the high-tension side.

Automatic overload relays appear to be used generally, and are of both the definite and inverse time limit type. The overload settings range from 100 to 300 per cent. overload and the definite time limits from ½ to 10 seconds.

The majority of the companies reported inability to carry a synchronous load through a heavy main line short-circuit, although a few claimed to be able to do so under such conditions when the arc was cleared by arc suppressers. The practice of nearly all the plants in locating line trouble is to sectionalize the line and test with the generator voltage and the patrol. One company uses a wheatstone bridge for this purpose, and two others employ a special loop test.

While most of the companies have had no trouble with oil switches, one reported trouble due to breakdown of the bushing from lightning or surges. Another had experienced trouble from repeated operation on short-circuits without overhauling, while a third said the type H-3 and K-10 switches had always opened short-circuits successfully, but sometimes the switches were nearly wrecked.

With regard to the use of reactance to balance charging current, one company reported the use of shunt inductance coils at one end of the line. These have a loading value of 2000 kv.-a. and are arranged for being cut in by steps. They have been found valuable in tying together two plants with little voltage disturbance.

⁂

Flywheel Explosion at Union Brewing Co., St. Louis, Mo.

At 1:25 a.m., on June 29, a flywheel burst, on a 100-ton ammonia compressor, at the Union Brewing Co.'s plant in St. Louis. A general diagram of the engine room and its surrounding is shown in Fig. 1. The flywheel was 14 ft. in diameter and 13x16-in. cross-section of rim, made in halves and secured by bolts through flanges in the rim and hub; it weighed 40,000 lb. The compressor was operated normally at 50 r.p.m., and was the largest of three in the plant.

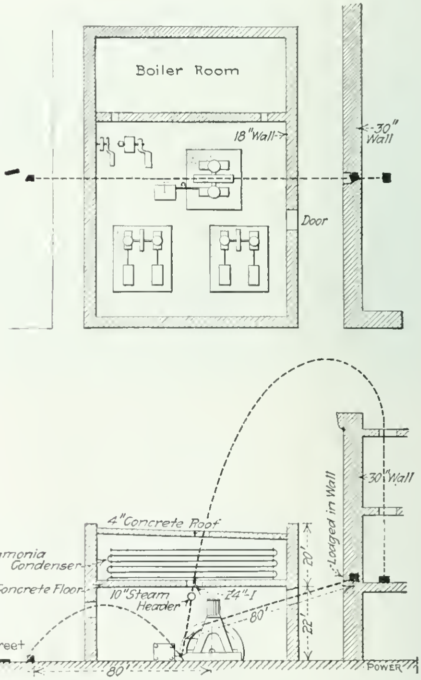


Fig. 1. Plan and Elevation of Plant, Showing Direction Taken by Flywheel Parts

The accident was caused by the working out of a small key, that fastened the bell-crank lever to the steam admission valve, on the crank-end when the admission valve was wide open, thus allowing the machine to run away and burst the flywheel by centrifugal force. As evidence that this was the cause, the feed water heater, which was out of the path of flying parts, was burst by the live steam pressure blowing through the exhaust port on the crank-end into it, the open steam valve permitting boiler pressure to follow the piston full stroke. The engineer observed the increased speed and attempted to stop the compressor, but the throttle was difficult to reach from the floor and hard to turn, and he was forced to leave before the throttle could be fully closed.

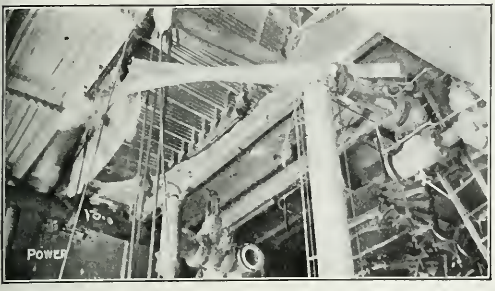


Fig. 2. Wreckage Caused by Flywheel Explosion, Looking at the Condenser and Steam Header

When the flywheel burst, one piece weighing about three tons went through the second floor, which was of concrete, cutting off an 18-in. I-beam, then through an ammonia condenser and concrete roof and came down through the concrete roof, through the third floor and came to rest on the second floor of an adjoining building.

Another large piece went up on an angle of about 20 degrees through the 18-in. brick wall of the engine room and lodged in the 30-in. wall of a building across the alley. A third piece struck a 10-in. extra-heavy steam header and tore off a section about 10 ft. long, Fig. 2, stripping off the threads from the flanges and bending the pipe double. It then went through a window and out into the street followed by one of the spokes. Fig. 3 shows the wreck caused by the accident. The ice machine was wrecked, ammonia condensers demolished, electrical and other machinery damaged.

Breaking of the steam header and ammonia piping caused the loss of 10,800 lb. of ammonia in the system, valued at $2700. That everyone in the plant was not instantly killed by the liberated liquid ammonia is probably due to the strong chemical affinity that ammonia has for water. Fortunately the section of the wheel that cut the ammonia pipes also cut the steam main so that the liberated ammonia combined with the liberated steam vapor, thus forming aqua-ammonia and preventing the death of those about the plant. Some of the employees held their heads out of the windows, while others rushed to cold storage rooms and shut themselves in to escape from the deadly fumes. None of the seven men on duty were injured. The financial loss was fully protected under a policy of flywheel insurance carried by the Fidelity & Casualty Co., of New York. Under this policy the full amount of the loss, $13,423, was paid four days after the accident occurred.

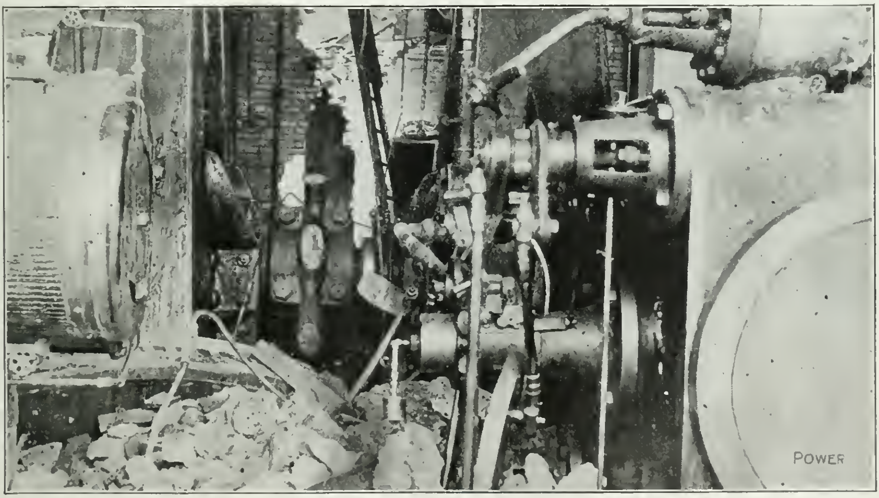


Fig. 3. One-Hundred-Ton Capacity Ammonia Compressor Wrecked by Flywheel Explosion

Recent Court Decisions

Digested by A. L. H. STREET

Condemnation of Land by Power Companies—The validity of the Alabama law which authorizes a power company to condemn dam sites, water rights, etc., including water rights of factories in excess of the needs of such factories at normal stages of the stream, is sustained in a long opinion recently announced by the Alabama Supreme Court in the case of Alabama Interstate Power Co. vs. Mt. Vernon-Woodberry Cotton Duck Co., 65 "Southern Reporter," 287. The decision proceeds upon the theory that use of property to develop electricity for distribution to the public is a public use, within the principle of law that limits the right to condemn land to cases where public use is involved. In the same opinion the right of a foreign power company to condemn land under the law is recognized.

Seattle Can Sell Power—Sale of power is an incidental part of the Seattle city lighting department, according to the supreme court of Washington, in a decision handed down in the case of Albert Chandler and wife against the City of Seattle, validating the $425,000 bond issue authorized a year ago for the construction of an auxiliary steam power plant on Lake Huron.

Because of the failure of the Legislature to mention the word "power" in authorizing the city to issue bonds for the establishment and maintenance of a lighting plant, C. B. Masslich, of Caldwell, Masslich & Reed of New York, who have passed on all Seattle's securities, raised the question as to whether all light and power bonds should not be a charge against the 5 per cent. of the assessed valuation allowed for general fund purposes rather than against the 5 per cent. authorized for water, light and power purposes. Masslich suggested a friendly suit in order to determine this question.

This decision affirms throughout that of the King County superior court, upholding the validity of the light and power bond issues in question.

Duty to Keep Electric Wires Insulated—An electric company which maintains wires extending through the branches of trees is bound to take notice of the habit of boys to climb trees, and must keep the wires insulated to avoid injury to trespassing boys. At least this is the holding of the North Carolina Supreme Court in the recent case of Benton vs. North Carolina Public Service Company, 81 "Southeastern Reporter," 448. The court recognizes in its opinion that this rule is not applied in all the states, but states that it finds support "not only in reason and a sound policy, but in a number of decided cases," including decisions of the highest courts of Mississippi, Kansas, Connecticut and Pennsylvania. In the North Carolina case it appears that the wire had been insulated, but that it became uncovered through friction between it and the nearby branches of the tree.

When Private Power Plant Becomes a Public Utility—"A corporation, organized under a charter authorizing only mining and sale of coal and the exercise of rights incidental to such business, but nevertheless engaged in the work of supplying, from an electrical plant installed and maintained primarily for the operation by electric power of its mining machinery and the lighting of its stores, offices, and tenement houses, electricity for lighting purposes to practically all such persons resident within the incorporated town in which its stores and offices are located as apply for such service, at uniform rates of compensation, wiring their buildings for its use, and furnishing them fixtures, is a public service corporation, within the meaning of the Public Service Corporation Act, and so much of its business as is of a public nature is subject to control and regulation by the Public Service Commission." (West Virginia Supreme Court of Appeals, Wingrove vs. Public Service Commission, 81 "Atlantic Reporter," 734.)

Coal Not Warranted to Be Dry—When nut and slack coal is sold without any understanding between the parties that it is to be used in an automatic stoker, there is no implied warranty on the part of the seller that the fuel will be dry, so as to be available for that use, according to a recent decision of the West Virginia Supreme Court of Appeals, announced in the case of Buffalo Collieries Co. vs. Indian Run Coal Co., 81 "Southeastern Reporter," 1055. In this case it appeared that a selling company bought nut and slack from a mining company for delivery direct to its customers; that first deliveries made to an electric company for use in a power plant proved satisfactory, but that when the mining company installed a washer at its tipple, deliveries of wet coal proved unsuitable for use in the electric company's automatic stoker, and on that company's complaint the selling company obtained coal for its use elsewhere and sought to hold the mining company liable for the cost of this fuel in excess of the contract price, on the theory that the mining company had impliedly warranted that the coal would be dry and suited to use in an automatic stoker, but the court decided in favor of the mining company, saying:

> This correspondence shows that the washed coal was better than the unwashed; that it contained more heat units, which is the most desirable quality in coal. It also tends to show that defendant regarded it of greater market value than the unwashed. The defendant's customer was the dissatisfied party, not defendant, and its complaint was not because of the quality of the coal. The gravamen of its complaint was that the washed coal would not work well in the automatic feeder, which carried the coal to the furnace. There is no evidence that plaintiff sold the coal with reference to its being used in any particular device for the handling of it, which required dry coal, and, therefore, there was no implied warranty that it would answer such purpose.

PERSONALS

W. O. Brooks was recently appointed operating engineer of the Abbeville (Ga.) Electric Light, Water & Power Co. Mr. Brooks succeeds J. J. Peterson.

E. E. Robinson is the recently appointed superintendent of the Southern Sierras Power Co.'s plant at Elsinore, Calif. P. L. Nourse was the former superintendent.

C. B. Arnold has been appointed operating engineer of the Intermountain Railway, Light & Power Co., Laramie, Wyo., This company is the successor to the Laramie Electric Co.

William Floyd Lee, chief engineer of C. W. Hunt Co., Inc., West New Brighton, S. I., N. Y., at a recent meeting of the board of directors, was elected vice-president and chief engineer of the company.

Jay G. Coutant, formerly engineer of plant of the Lima Locomotive Corporation, Lima, Ohio, who has specialized in the burning of powder fuel and water gas, has taken up the same work for the Railway Materials Co., Chicago, Ill.

Daniel Webster Mead, professor of engineering in the University of Wisconsin, Madison, Wis., has been appointed a member of a board of engineers for the prevention of floods in Eastern China through a $20,000,000 reclamation project.

Alexander G. Christie, associate professor of steam engineering, University of Wisconsin, has been appointed associate professor of mechanical engineering in the College of Engineering, which Johns Hopkins University is now organizing and building.

A. A. Potter, for several years professor of steam and gas engineering at the Kansas State Agricultural College, was made dean of the engineering division and director of the engineering experiment station of the same institution. Mr. Potter will still retain the professorship in steam and gas engineering.

OBITUARY

QUIMBY N. EVANS

Quimby N. Evans, senior partner of the firm of Evans, Almirall & Co., New York City, contractors for heating, ventilating and power equipment, died suddenly on Monday night, July 6. Mr. Evans was one of the old timers in the business, having been in partnership with Frederick Tudor in Boston as F. Tudor & Co., in the seventies. In 1880, he formed a partnership as the Q. N. Evans Co., doing business in Boston and New York, and in 1885 formed the Q. N. Evans Construction Co., in New York. In 1892 Mr. Almirall became associated with him, and two years later the present copartnership of Evans, Almirall & Co. was formed and has been in existence ever since. During the past few years Mr. Evans has not been actively engaged in the business, having felt that he could leave it in younger hands. His death was unexpected. Mr. Evans will be missed by a large circle of friends. The business of Evans, Almirall & Co. will continue as in the past.

NEW PUBLICATIONS

ELEMENTARY MANUAL OF THE STEAM ENGINE. By E. V. Lallier. Published by D. Van Norstrand Co., New York. Size, 5x7½ inches; 266 pages, illustrated. Price, $2 net.

From the title one would expect a treatise on the steam engine, but will find only about one-third the text covering this subject, the remainder being devoted to boilers, chimneys, pumps, steam turbines, pipes and fittings and internal combustion engines.

The method of treatment is first a description of the engine, followed by computations relating to its performance and then a brief but practical discussion of the fundamental theory. This order is the reverse of that usually found in textbooks, but has much to commend it to the practical man.

The part of the text dealing with the steam engine is good, in so far as it goes, the only criticism which might be offered being adherence to the old steam tables, based on Regnault's formulas, which have now been discarded by most authorities. Also, the author coins the expression "H. U." for heat unit, meaning a British thermal unit (B. t. u.), which might lead to confusion; and further classifies steam turbines under "rotary engines" in contradiction to the generally accepted definitions of these two types of prime movers.

The chapter on internal combustion engines contains many loose and misleading statements and might well have been omitted altogether. The only excuse for its inclusion would be its use to the operating engineer having charge of gas or oil engines, but it does not well serve this purpose since the gasoline engine is taken as the model with the statement that its description will cover all types.

NEW EQUIPMENT

ATLANTIC COAST

The Connecticut Co., Hartford, Conn., will make improvements to its power plant on Commerce St.

Bids will be received by E. C. Rider, Supt. Northern New York Institution for Deaf Mutes, Malone, N. Y., until July 22 for furnishing electric generating equipment at the institution.

Bids are being received by the Luna Park Amusement Co., Coney Island, New York, N. Y., for the construction of a complete power plant.

A municipal electric-light plant costing $30,000 will be constructed at Butler, N. J.

The Albion Light & Power Co., Albion, Penn., is in the market for a boiler and additional equipment. T. H. Flower is Treas.

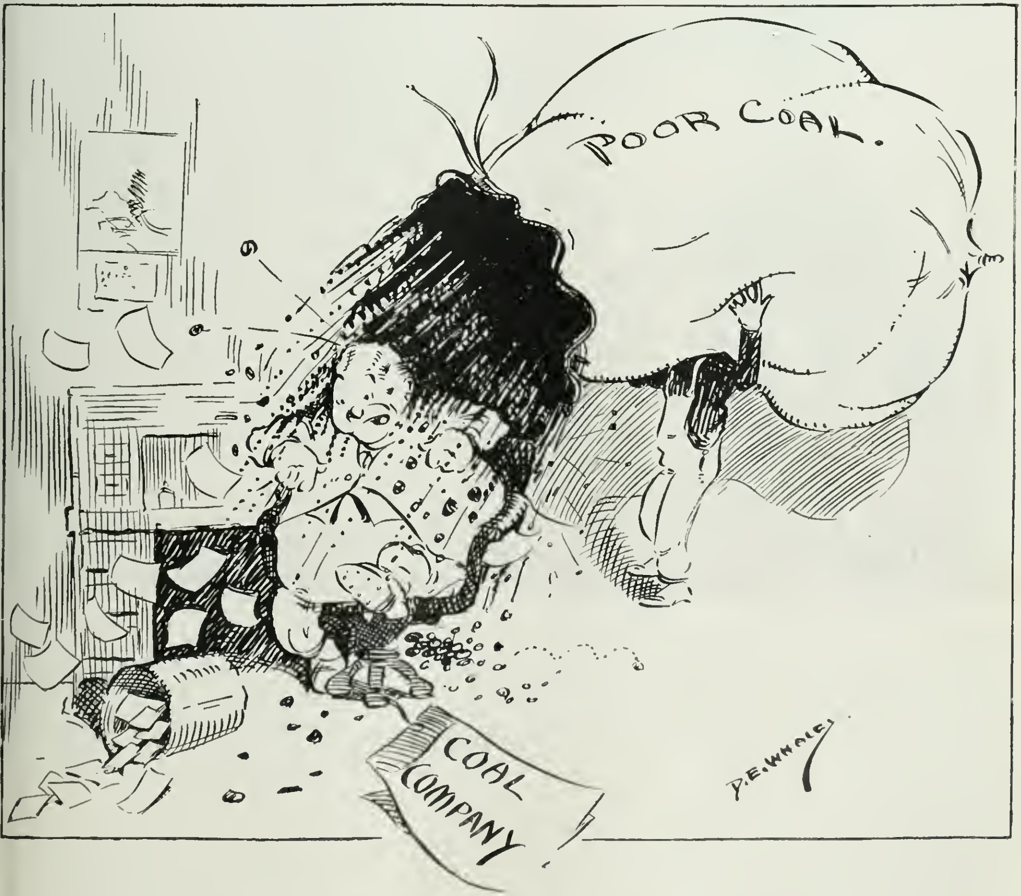
Plans are being prepared by Jacoby & Weishampel, Commonwealth Bldg., Allentown, Penn., for the erection of a power station for the Panther Valley Electric Light Co., Lansford, Penn.

SOUTHERN STATES

The electric-light plant of H. A. Smith, Gurley, Ala., which was recently destroyed by fire, will be rebuilt.

POWER

Vol. 40 NEW YORK, JULY 28, 1914 No. 4



IF WE COULD HAVE OUR WAY!

The Moline Power Plant

By Thomas Wilson

SYNOPSIS—From belt drive to a modern plant having a capacity of 21,500 kw. Its features are special coal chutes, individual steel stacks, the latest type of impulse-reaction turbine and a double-unit arrangement of metering heater and metering dividing box.

❋

The Moline power station of the Tri-City Railway & Light Co., which is controlled by the United Light & Railways Co., has undergone a rapid evolution from the simplest kind of plant to a modern power station of magnitude. It is at the foot of Fourth St., on the banks of the Mississippi River, at a narrow passage between the main land and Sylvan Island. At this point, a water power having an average head of about 10 ft. had been developed and it has always been run in conjunction with the steam plant.

About a dozen years ago, the station was equipped with cross-compound engines turning by rope drives a line shaft running the length of the station. The shaft was also turned by a rope drive running over a 250-ft. bridge to the watersheds. Naturally, the generators were belted to the line shaft and the jet condensers serving the engines were also belted units. The boilers were hand fired and there was no coal-handling machinery to reduce the labor in this department. The belted units were gradually discarded, the rope drive from the water power plant was taken out and generators were attache to the waterwheels; new boilers, equipped with stoker and superheaters, were installed and bucket conveyor handled the coal and ash.

In 1908, at the time this plant was described in Power there were eleven 500-hp. boilers, and in the engine roo two 1000-kw. cross-compound condensing units directl connected to revolving field alternators and exhaustin into vertical, double-acting jet condensers, one 1500-kw and one 3000-kw. reaction turbine, one of the older unit still connected to a small portion of the line shaft, and couple of motor-generator sets.

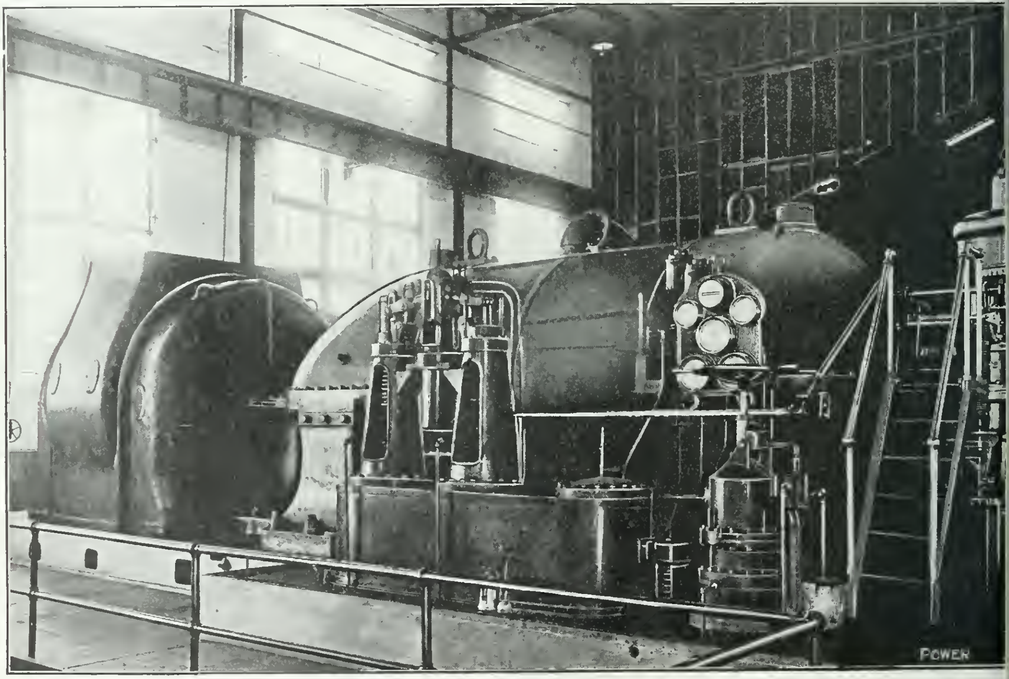


Fig. 1. The 10,000-Kw. Unit in the Moline Power Plant

Due to the rapid growth of the three cities, to the ex tension of the lines to Muscatine and to the small town in the vicinity, the increase in the load was phenomena It soon passed the station capacity and in 1910 it wa necessary to install a 6000-kw. turbine. The plant wa nearly filled with generating equipment, but instead o enlarging the building, one of the cross-compound en gines was removed to make way for the above unit an a 10,000-kw. turbine, Fig. 1, the latter being ready fo operation by the first of last December. One of the larg engine units, Fig. 8, still remains, but when the loa requires it, this machine will be replaced by a secon 10,000-kw. turbine, which will occupy less floor spac than the 1000-kw. engine and develop ten times the power at a much lower steam rate.

At present, the plant has a total boiler capacity of 7900 hp., and, at rating, 21,500 kw. in generating units, making a ratio of 1 to 2.7, respectively. The low steam rate of the large turbine units has lessened the demand on the boilers. Last winter the load in the steam plant ran about 135,000 kw.-hr. per day of 24 hr., in the water plant 30,000 kw.-hr. per day and the same at the Sears plant, which also belongs to the system. From 1 to 5 a.m., when the demand is light, the water plants, having an alternating-current capacity of 2750 kw. in three units and 500 kw. in a direct-current machine at Moline and 2100 kw. at Sears in six vertical units of 350 kw. each, carry the entire load.

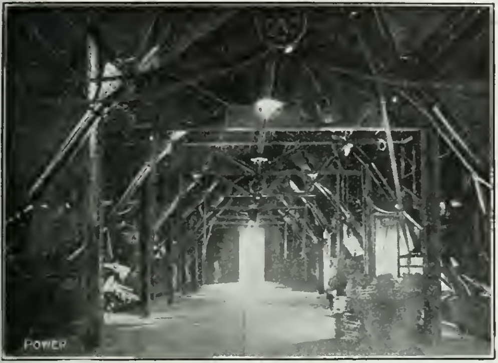


Fig. 2. Firing Aisle of the Boiler Room

In the three cities there is supplied by the company all of the lighting, street and interior, all of the current for street-railway service and 80 per cent. of the power required in all the industrial plants, besides the service to the surrounding towns. The current is generated at 4800 volts, two-phase, 60-cycle. For nearby towns it is distributed at 4800 volts and for Muscatine, 30 miles distant, the voltage is 33,000. Ultimately, all transmission from the power house to the five substations will be at 33,000 volts. It is with the steam plant, however, that this article has to do. There are some interesting features in the boiler room, Fig. 2, the large turbine is of interest, and there is a special metering heater, the only one of its kind in the Central States.

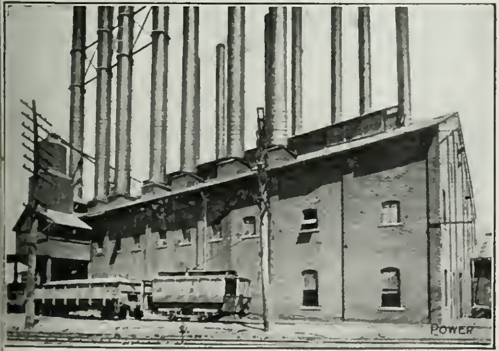


Fig. 3. A "Forest" of Individual Steel Stacks

Boiler Room

The equipment includes eleven 500-hp. and four 600-hp. water-tube boilers arranged in two rows and facing a central aisle. The operating pressure is 200 lb. gage, with 110 deg. of superheat. All of the boiler furnaces have chain grates.

Each boiler has an individual steel stack, Fig. 3, and although this practice was due to the frequent additions made, it is really in line with modern development. The tendency is to reduce the number of boilers served by one stack, and in some of the most recent plants the number has been cut down to two. There is no breeching, and as the gases have a straight flow up into the stack, there is only the resistance of the setting to prevent getting the maximum draft over the fire. At the Moline plant, the individual stack is well liked. It gives independent control of each boiler, the initial cost as compared with an equivalent in four brick or concrete stacks is less, and by painting at least every two years the steel stack is good for 15 to 20 yr. of service. One objection is the number of stacks. There are now fifteen, and with the increase in the boiler capacity expected in the near future, more will be needed if the same practice is followed. The steel stacks may then be replaced by four concrete chimneys of equivalent capacity.

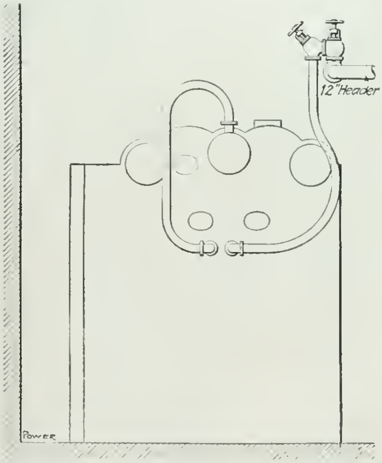


Fig. 4. Typical Boiler Connection to Header

The stacks have a uniform height of 150 ft. above the grates. Those for the smaller boilers are 5½ ft. in diameter and the four serving the 600-hp. units are 6 ft. in diameter, providing in each case 0.017 sq.ft. of area per horsepower of rating. The draft above the damper runs about 0.9 in. of water and reduces over the fire to 0.3 in. When burning Illinois screenings, a fuel bed 5 in. thick is carried. As received, the coal runs about 10,000 B.t.u. and an evaporation from and at 212 deg. or 7 lb. per pound of coal as fired, is obtained. On the present light load, about 3½ lb. is required per kilowatt-hour, but with the heavy load next winter a reduction to 2½ lb. is expected.

Coal and Ash Handling

Coal delivered in railway cars is dumped into a hopper under the siding. A 22-in. belt carries it to either of two continuous bucket conveyors, of which there is one for each row of boilers. Both deliver into a sectionalized steel bunker which has 16 compartments and a total capacity of 1200 tons, situated over the firing aisle. Either conveyor will normally handle 50 tons per hour. There is provision for chuting into the conveyors the fine coal dropping through the grates.

From the bunker, the coal is chuted to the stoker hoppers, and in this connection trials have been made to secure a chute of proper form. The usual single spout arranged to swing from one end of the hopper to the other was first tried. As long as the gate was closed after filling the hopper, this type was satisfactory, but it was often left open and the pressure at the point at which the chute was resting caused a heavier feed on that portion of the grate in line with it; uneven burning of the fuel was the result. A flared chute, covering the entire hopper, was next tried, but in this the coal separated, the coarse pieces rolling to the outside and the fine coal feeding down the center. A Y-outlet gave the same results as the single spout only that the feed was forced in two places and it also separated the fine and coarse coal. It was replaced with a three-legged chute obtained by using a double lateral fitting. The results were still unsatisfactory until a baffle plate was inserted at the back of the hopper to take the weight of the coal and mix it as it came from the chute. With this last provision the chute is now foolproof. There is no occasion to swing it, nor is it necessary to shut the gate. The feed is continuous and no particular watching by the firemen is required.

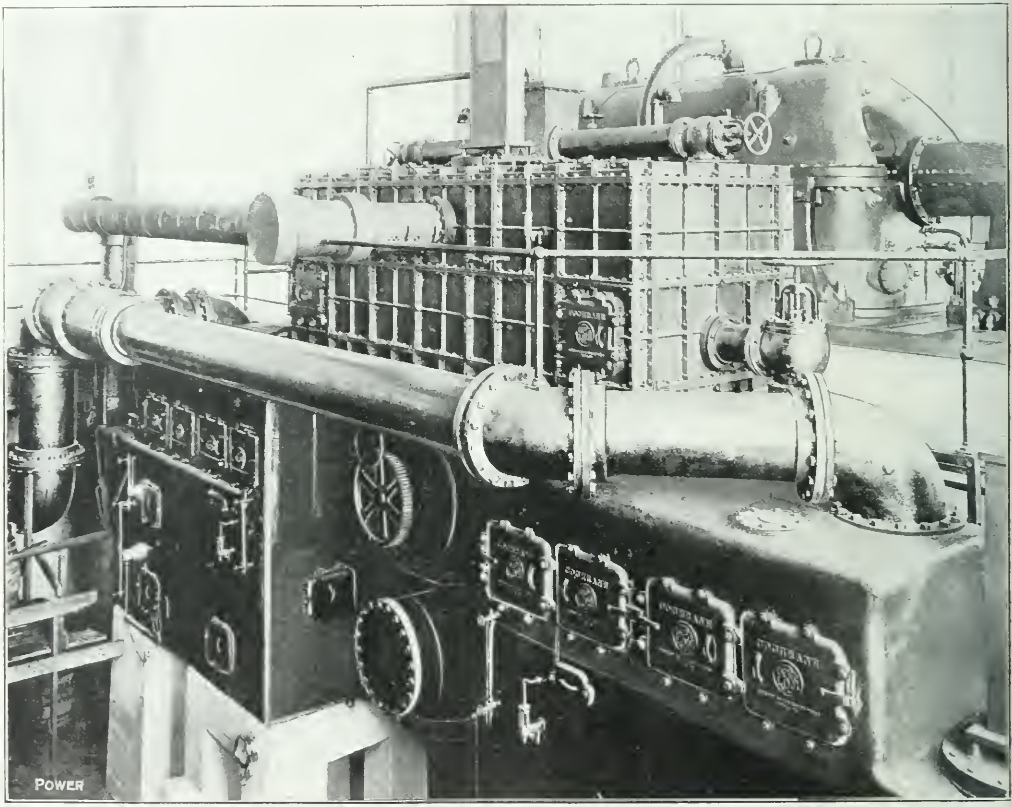


Fig. 5. Multiple-Unit Metering Heater and Dividing Box

Ashes are handled by a pneumatic system through an 8-in. pipe. The horizontal run along the ashpits is about 175 ft., the lift about 80 ft. and the run over the boiler-room roof to the separating tank about 100 ft. From the latter, the ashes are delivered to a bunker beside the railway track. In the horizontal pipe over the roof, water is introduced to kill the fire in the ash and eliminate clinkering in the separator or bunker. It also prevents dry ash reaching the blower.

The main header, which is made of steel to withstand the superheated steam, loops the coal bunker, passing over the boiler fronts, Fig. 4. It is 14 in. on one side, 12 in. on the other and is so valved that it may be sectionalized every three boilers. The header is anchored at the four corners of the boiler room and a U-bend in each of the longer runs provides for expansion. Saturated steam from the boiler drum passes down to the superheater, entering through the side of the setting and, returning through a sickle bend which provides for expansion, it enters the header through an angle body, nonreturn valve and a straight-angle valve mounted directly in the header. Taps for the main units are carried over to the boiler-room wall, where they are dropped and pass to the various machines underneath the engine-room floor.

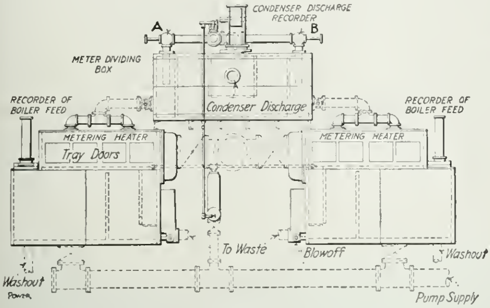


Fig. 6. Layout of Heater and Connections

The Feed Water

To supply the feed water to the boilers, there are three 14 and 8¾ by 16-in. duplex pumps and one steam-turbine-driven centrifugal pump having a capacity against the boiler pressure of 450 gal. per min. Ordinarily, the centrifugal pump is used, or if this is down for any reason, the other three units. Duplicate 6-in. feed lines loop all the way around the boilers. They are liberally cross-valved and 2½-in. taps lead to the boilers. Condensate is collected in the heater from the hotwells of the various turbines, and the makeup comes from the oil cooler of the large turbine. This is virtually a surface condenser with straight tubes placed alongside the machine. The heat in the oil is thus utilized in the boiler feed.

A Special Heater

The feed-water heater, Fig. 5, is of the recently developed multiple type. There are two metering heaters, each having a capacity to handle 300,000 lb. of water per hr., or a total of 600,000 lb. The dividing box, having a capacity of 500,000 lb. per hr., is arranged above the two heaters. Condensate from the condensers enters the central portion of the box and overflows through a V-notch on either side into the end compartments; the water is thus equally divided between the two heaters and an automatic recorder shows the amount. Makeup water is introduced into the end compartments through pipes *A* and *B*, Fig. 6. Here again the division is equal as a makeup-water dividing box equally divides an automatically regulated supply and distributes it to the outboard sides of the condensate dividing box. As the water enters the compartments directly, it is not metered. With the condensate, it passes to the heaters, where the total quantity fed to the boilers, which includes condensate, makeup water and the steam from the auxiliaries condensed, passes over the other weirs, a meter on each heater recording the amount. The difference between the sum of the heater readings and the reading of the meter on the dividing box represents the steam to auxiliaries, water lost by leakage, blowing down the boilers, etc. If it is desired to determine the water rate on an individual unit, it can be done with one heater and the dividing box, while the other heater is reserved for the balance of the plant. To conform with a 29-in. vacuum obtained on the large unit, the meter on the dividing box is calibrated for a water temperature of 80 deg. and those on the heaters for 210 deg.

Generating Equipment

The number and capacity of the generators were previously given; all, with the exception of the 1000-kw. engine unit, are turbine-driven. The smaller units are of the reaction type and were standard when installed, while the 10,000-kw. machine embodies the improvements which have attended the development of the larger turbines. The machine is of the combination impulse-reaction type divided into high-, intermediate- and low-pressure elements contained in the one casing. In the impulse or high-pressure element at the center of the machine, the steam is expanded from 200 to 80 lb. and, dividing equally, passes in opposite directions through the intermediate blading to the low-pressure elements. The reaction end of the turbine is double-flow, with an exhaust outlet at either end of the machine. The primary valve is designed to carry 10,000 kw. and, with the help of the secondary valve, 15,000 kw. To improve the economy of the ma-

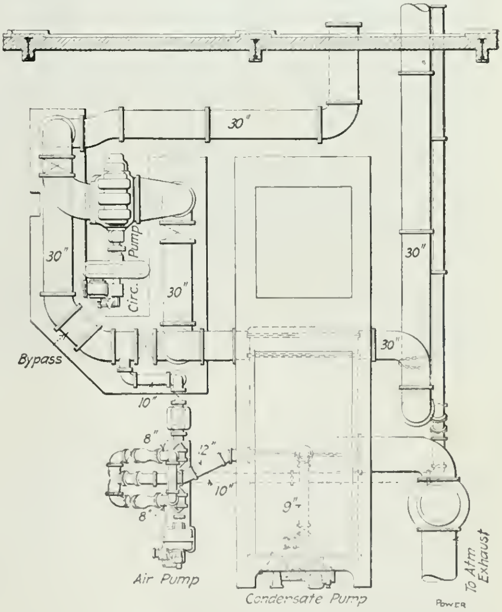


Fig. 7. Condenser and Auxiliaries of 10,000-Kw. Unit

chine when the load is between 10,000 and 12,500 kw., a hand-operated nozzle supplementary to the primary valve has been provided. It is thus possible to develop 12,500 kw. before the secondary valve is called into service.

The water rate guaranteed for the machine was 13.7 lb. per kw.-hr. at 200 lb. initial pressure, 100 deg. superheat and a 28-in. vacuum. As a matter of fact, at two-thirds load, an absolute pressure of ½ in. was maintained and at full load a vacuum of nearly 29 in. The rate is known to be better than the guarantee, but no definite figures are available. On a similar unit, a rate of 12.8 lb. per kw.-hr. at 28-in. vacuum has been obtained, and with 29 in. this was reduced to 12.5 lb.

The supply pipe is 14 in. in diameter. At normal load and a rate of 13.7 lb. per kw.-hr., this would call for 137,000 lb. of steam per hour. As the pressure is 200 lb. gage and the superheat at the turbine 100 deg., this is equivalent to 345,240 cu.ft. per hr. or 5754 cu.ft. per min. The velocity would be approximately 5200 ft. per min., and with the secondary valve open, it would increase to 8000 ft. per min. At 28 in. of vacuum, the exhaust is discharged through the outlets at a rate of 14,000 ft. per min.

The condenser, which is immediately under the turbine, is of the surface type, with ample spaces through the tube sections for the free passage of the steam and with two inlets to match the turbine-exhaust openings. The drop through the condenser is only 0.08 in. It contains 19,000 sq.ft. of surface in 1-in. tubes, which gives a ratio of 1.9 sq.ft. to every kilowatt of turbine rating. To condense the 137,000 lb. of steam per hour, 9,500,000 lb. of water (a ratio of 70 to 1) is passed through the condenser. This amount is maintained constant and the vacuum allowed to vary slightly. As a reason for this practice, the circulating water is drawn from the river just above the dam. As the tailrace into which the water is discharged is 10 ft. lower, it is necessary to use the circulating pump only to start the flow. When it has been established, the siphoning action due to the difference in head will maintain it. As there is bypass connection around the pump, it is a simple matter to change over.

A Leblanc air pump, driven by a 100-hp. turbine, and having a capacity of 960 cu.ft. per min., is used. Of water, 1600 gal. per min. is required, and as its temperture is only raised ½ deg., it could be used in the condenser or recirculated through the pump with a little makeup to keep down the temperature. In the present plant, there is plenty of water so that the discharge from the pump is returned to the river.

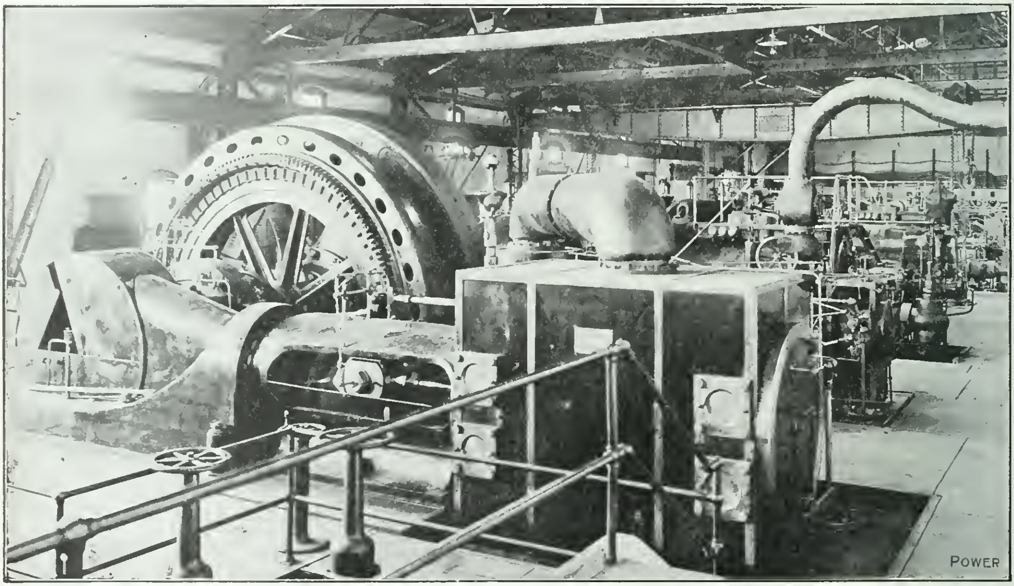


Fig. 8. Compound Engine Unit and the Small Turbines

The circulating pump, which is used only at starting, has a capacity of 20,000 gal. per min., and is driven by a 175-hp. turbine. The condensate pump is a single-stage centrifugal, driven by a 25-hp. turbine; its capacity is 900 gal. per min. All of the auxiliaries for the large unit are of the rotary type and are driven by steam turbines. The same is true of the 6000-kw. machine, with the exception of the air pump, which is a direct-acting piston pump. For the two smaller turbines, the circulating pumps are centrifugal and engine driven. The air pump for the 1500-kw. unit is of the double-acting, valveless-suction type, while the air pump on the 3000-kw. turbine is a single-acting triplex pump of the same type.

It is needless to say that all of the condensers for the turbine units are of the surface type, while the 1000-kw. Corliss has a vertical double-acting jet condenser capable of maintaining a vacuum of 27 in. On the two smaller turbines the vacuum averages about 28 in. and on the

6000-kw. turbine, 28½ in. For the latter the condenser has 18,800 sq.ft. of surface, or 3.13 sq.ft. per kilowatt of rating. Of the other two, the larger has 10,000 sq.ft. of surface as compared with 4000 sq.ft. for the condenser serving the 1500-kw. turbine. This gives 3⅓ and 2⅔ sq.ft. per kilowatt of turbine rating, respectively. Fig. 7 shows the layout of the condenser and auxiliaries of the 10,000-kw. unit.

The steam rates for the smaller units are naturally higher than for the machine recently installed. The accompanying table will, however, reduce the condensing equipment of the four turbine units to a basis of steam condensed per square foot under the present conditions of pressure and superheat, the vacuum to be 28 in. and the steam rate that obtained at normal load.

The steam consumptions are taken from the guarantees furnished at the time the machines were installed. It was not until after the 600-kw. unit had been put in service that the boilers were equipped with superheaters, so that the operating conditions were 175 lb. pressure and no superheat. With the 100 deg. of superheat now available and the increase of 25 lb. in pressure, the water rate

PRINCIPAL EQUIPMENT OF MOLINE POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
11	Boilers	Stirling water-tube	500 hp.	Generation of steam	200 lb. pressure, 110 deg. superheat	Babcock & Wilcox Co.
4	Boilers	Stirling water-tube	600 hp.	Generation of steam	200 lb. pressure, 110 deg. superheat	Babcock & Wilcox Co.
15	Superheaters	Foster	465 and 550 sq.ft.	Superheat steam for turbines	Temp. steam, 500 deg. F	Power Specialty Co.
8	Stokers	Chain grate	100 sq.ft.	Boiler furnace	5-in. fuel bed, Illinois screenings	Green Engineering Co.
7	Stokers	Chain grate	110 sq.ft.	Boiler furnace	5-in. fuel bed, Illinois screenings	Illinois Stoker Co.
3	Coal conveyors	Belt	21 in. wide	Track hoppers to main conveyors	3300 ft. per min., 75 tons per hr	C. W. Hunt Co., Inc.
3	Motors	Induction	5 hp.	Driving belt conveyors	440 volt, two-phase	Westinghouse Elec. & Mfg. Co.
1	Coal crusher		50 tons per hr.	Crush coal	Motor driven	C. W. Hunt Co., Inc.
1	Motor	Induction	10 hp.	Driving crusher	440 volt, two-phase, 850 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Coal conveyor	Pivoted bucket	50 tons per hr.	From belt conveyors to bunkers	400 ft. per min., 50 tons per hr.	Jeffrey Mfg. Co.
1	Motor	Induction	15 hp.	Driving conveyor	440 volt, two-phase, 850 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Coal conveyor	Pivoted bucket	50 tons per hr.	Belt conveyors to bunkers	420 ft. per min., 50 tons per hr	C. W. Hunt Co., Inc.
1	Motor	Induction	15 hp.	Driving conveyor	440 volt, two-phase, 850 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Ash system	Pneumatic	9 tons per hr.	Removal of ash		Green Engineering Co
1	Exhauster	Suction	16 in.	Vacuum on ash system	6 oz. vacuum, 3600 r.p.m.	General Electric Co.
1	Motor	Induction	50 hp.	Driving exhauster	440 volts, two-phase, 3600 r.p.m.	General Electric Co.
3	Pumps	Duplex	14x8¾x16 in.	Boiler feed	200 lb. pressure	Epping-Carpenter Co.
1	Pump	Centrifugal	5 in.	Boiler feed.	3000 r.p.m., 420 gal. per min.	Westinghouse Machine Co.
1	Turbine	Horizontal reaction	30 hp.	Driving feed pump	200 lb. pressure, 3065 r.p.m.	Westinghouse Machine Co.
1	Heater	Cochrane multiple unit	600,000 lb. per hr.	Heat boiler feed water	Exhaust from auxiliaries	A Sorge, Jr., & Co.
1	Turbine	Impulse-reaction	10,000 kw.	Main unit	200 lb. pressure, 100 deg. superheat, 1800 r.p.m.	Westinghouse Machine Co.
1	Generator	Alternating current	10,000 kw.	Main unit	4800 volts, two-phase, 1800 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Condenser	Surface	19,000 sq.ft.	On 10,000-kw. unit	29 in. vacuum	Westinghouse Machine Co.
1	Air pump	Leblanc rotary	960 cu.ft. per min.	Air from condenser	2500 r.p.m.	Westinghouse Machine Co.
1	Turbine	Horizontal reaction	100 hp.	Drive air pump	200 lb. pressure	Westinghouse Machine Co.
1	Circulating pump	Single-stage centrifugal	20,000 gal. per min.	Water to condenser	1000 r.p.m.	Westinghouse Machine Co.
1	Turbine	Horizontal reaction	175 hp.	Drive circulating pump	200 lb. pressure, 1000 r.p.m.	Westinghouse Machine Co.
1	Condensate pump	Centrifugal	900 gal. per min.	Condensate to heater	200 r.p.m.	Westinghouse Machine Co.
1	Turbine	Horizontal reaction	25 hp.	Driving condensate pump	200 lb. pressure, 2000 r.p.m	Westinghouse Machine Co.
1	Turbine	Horizontal reaction	6000 kw.	Main unit	200 lb. pressure, 100 deg. superheat, 1800 r.p.m.	Westinghouse Machine Co.
1	Generator	Alternating current	6000 kw.	Main unit	4800 volts, two-phase, 1800 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Condenser	Surface	18,800 sq.ft.	On 6000-kw. unit	28½ in. vacuum	Henry R. Worthington
1	Air pump	Direct acting	30x24 in.	Air from condenser	200 lb. pressure, 60 r p.m.	Laidlaw-Dunn-Gordon Co.
1	Circulating pump	Centrifugal	24 in.	Water to condenser	785 r p.m.	Henry R. Worthington
1	Turbine	Horizontal reaction	110 hp.	Driving circulating pump	200 lb. pressure, 785 r.p.m.	Kerr Turbine Co.
1	Condensate pump	Centrifugal	4 in	Condensate to heater	1500 r.p.m.	Henry R. Worthington
1	Turbine	Horizontal reaction	20 hp.	Driving condensate pump	200 lb. pressure, 1500 r.p.m.	Kerr Turbine Co.
1	Turbine	Horizontal reaction	3000 kw.	Main unit	200 lb. pressure, 100 deg. superheat, 1200 r.p.m.	Westinghouse Machine Co.
1	Generator	Alternating current	3000 kw.	Main unit	4800 volts, two-phase, 1200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Condenser	Surface	10,000 sq.ft.	On 3000-kw. unit	28 in. vacuum	C. H. Wheeler Mfg. Co.
1	Air pump	Mullan single-acting triplex		Air from condenser	75 r.p.m.	C. H. Wheeler Mfg. Co.
1	Engine	Simple vertical	12x10	Driving air pump	200 lb. pressure, 75 r.p.m.	C. H. Wheeler Mfg. Co.
1	Circulating pump	Centrifugal	18 in.	Water to condenser	400 r.p.m.	Morris Machine Works
1	Engine	Simple vertical	12x14 in.	Driving circulating pump	200 lb. pressure, 400 r.p.m.	Morris Machine Works
1	Turbine	Horizontal reaction	1500 kw	Main unit	200 lb. pressure, 100 deg. superheat, 1200 r.p.m.	Westinghouse Machine Co.
1	Generator	Alternating current	1500 kw	Main unit	4800 volts, two-phase, 1200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Condenser	Surface	4000 sq.ft	On 1500-kw. unit	28 in. vacuum	C. H. Wheeler Mfg Co.
1	Air pump	Mullan steam driven, double-acting	8x18x12 in.	Air from condenser	200 lb. press., 80 r p.m.	C. H. Wheeler Mfg. Co.
1	Circulating pump	Centrifugal	12 in.	Water to condenser	500 r p m.	The Blake & Knowles Steam Pump Works
1	Engine	Simple vertical	8x9 in.	Driving circulating pump	200 lb. press., 500 r.p.m.	The Blake & Knowles Steam Pump Works
1	Engine	Cross-compound	24x50x48 in.	Main unit	200 lb. pressure, 100 r.p.m.	Allis-Chalmers Co.
1	Generator	Alternating current	1000 kw	Main unit	4800 volts, two-phase, 100 r.p.m.	Allis-Chalmers Co.
1	Condenser	Vertical double-acting jet	18x36x20 in.	On engine unit	27 in. vacuum.	Dean Bros Steam Pump Works
1	Exciter	Direct current	150 kw	Excitation main units	125 volts, 250 r.p m.	Westinghouse Elec. & Mfg. Co.
1	Engine	Simple	12x18 in.	Drive exciter	Noncondensing, 250 r.p m.	Skinner Engine Co.
2	Exciters	Direct current	50 kw	Excitation main units.	Driven by water wheels.	Westinghouse Elec. & Mfg. Co.
2	Exciters	Direct current	50 kw	Excitation main units	Motor driven	Westinghouse Elec. & Mfg. Co.
1	Crane	Electric	35 tons	Engine room		Whiting Equipment Co.
1	Crane	Hand operated	10 tons	Engine room		Northern Engineering Works

should improve about 12 per cent. On this assumption, the 6000-, 3000- and 1500-kw. turbines at full load, 28-in. vacuum and 90 per cent. power factor, would require 14.7, 17 and 18.8 lb. per kw.-hr., respectively.

CONDENSER SURFACE AND STEAM CONDENSED

Kw. Rating, Turbine	Condenser Surface, Sq.Ft.	Surface per Kw., Sq.Ft.	Steam Rate, Lb. per Kw.-Hr.	Total Steam, Lb. per Hr.	Steam Condensed per Sq.Ft. of Surface, Lb.
10,000	19,000	1.9	13.7	137,000	7.2
6,000	18,800	3.13	14.7	88,200	4.7
3,000	10,000	3.33	17	51,000	5.1
1,500	4,000	2.66	18.8	28,200	7.05

It should be taken into account that the 6000 3000- and 1500-kw. turbines have reciprocating dry-air pumps and that the surface of the condensers was based on a heat transfer of 350 B.t.u. The large unit employs a rotary wet-air pump and the condenser was based on a heat transfer of 500 B.t.u.; in fact, the latter figure is now standard for most of the large condenser companies. If the last three condensers in the table had been based on the higher heat transfer, the total surface in each case would be reduced to seven-tenths of the figure given and the steam condensed per square foot raised in proportion. The condenser for the 1500-kw. unit was designed to give a vacuum of 28 in., when the turbine was running at two-thirds load, so that 5.4 rather than 7.05 would be a representative figure. This was common practice at the time it was put in service. On the other hand, it would be possible to get 13,750 kw. from the large turbine and still maintain a vacuum of 28 in. with 65 deg. cooling water. At this load, the steam consumption would be 208,000 lb. and the condensation per square foot of surface nearly 11 lb.

For the recent installations and changes that have been made, W. S. Swarting was engineer in charge of construction, E. L. Cameron is chief engineer of the plant, and F. W. Reimers, general manager of the company.

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Wasteful Ignorance

By Frank W. Hudson

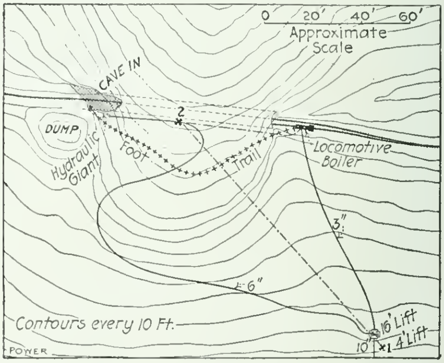
The man who believes in learning his trade solely by experience is ofttimes with his hands in empty pockets. While technical education is not the alpha and omega of mechanical success, it is undoubtedly the foundation upon which we must build.

Several years ago a railroad in the West suffered the loss of twelve days' crippled passenger and freight transportation service by the roof of a tunnel falling in, caused by a piledriver tower that was not lowered enough to clear. All the available men of the system, numbering about 1000, were dispatched to the scene.

With them came a steamfitter and pump man. He was a husky, broad-shouldered fellow who ridiculed the idea of a "book education," stating that he had "learned his trade right by practical experience" and informing one of his men that he did not want him to tell him anything. He was no doubt good at erecting small pumps for emptying oil cars or filling water tanks, but in this case it meant installing a giant to wash the earth down into sluice boxes and out on the dump as an auxiliary to the steam shovel employed in clearing the tunnel. This was unsuccessful because of the steamfitter's ignorance of the influence of the altitude, the best location for the pumps and the right manner of connecting them.

The pumps were of the commonly used duplex type, one having a 10-in. suction and 8-in. discharge, the other an 8-in. suction and 6-in. discharge. The point of delivery was about one hundred and fifty feet elevation and probably 600 ft. between the intake and discharge. A locomotive was sidetracked 400 ft. from the pumps to supply the steam. The altitude was 3000 ft. above the sea level. The illustration shows that the conditions were ideal, and this installation should have been completed by sundown. But what a delay a lack of a little knowledge can sometimes create! Eleven days later the tunnel had been cleared but without the use of the pumps.

The first thing done was to move both pumps near the river and connect both suctions to the 10-in. pipe that the large pump required and down into the river 16 ft. below. The discharges were then bushed down and connected into a 6-in. delivery pipe. Instead of running straight for a possible 600 ft. to the giant, an S-bend was run up the hill, using nearly a thousand feet of pipe. When the pumps failed to deliver water he said: "She's got me buffaloed. There's no reason why she won't work." It didn't, however, and he finally let the pumps down to within 6 ft. of the water; then he only got small results.



Conditions Near Cave-In

With an ounce of sense, he would have placed the large pump at the cross marked "1" within four feet of the river, and the smaller one at "2." Then he should have laid the pipe between the two, as indicated by the dotted lines. However, this much more experience was added to his education.

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Proportionate Wages—Paying $125 to $150 a month to a fire-room foreman who has the handling of thousands of dollars worth of coal, may seem excessive to some managers, but in several progressive stations rates as high as 45 cents per hour are paid firemen so as to attract efficient men.

⁂

Anthracite Coal Production in 1913—The production of anthracite again broke the record in 1913, exceeding the highest previous output by nearly 1,000,000 tons, according to figures compiled by E. W. Parker, coal statistician of the United States Geological Survey. Including the coal recovered from old culm banks and a small quantity dredged from the Susquehanna River, the production for the year was 81,718,680 long tons, valued at $195,181,127, compared with 75,322,855 tons, valued at $177,622,626 for 1912. This is an increase of over 6,000,000 tons in quantity and more than $17,500,000 in value. The previous highest record was 80,771,488 long tons, in 1910.

Poor Brine Circulation Cause of Decreased Output in Ice Plants

By Peter Neff

The brine circulation about the cans in an ice tank is one of the governing factors in ice production, and, while a considerable amount of thought has been given to this subject, it is surprising to find how often conditions exist which indicate that the arrangement used had not been sufficiently thought out to meet these conditions.

Propellers are now quite universally used for producing the circulation of the brine, and when properly applied are both economical and effective.

Where coils are used in the ice tank there is less liability for improper circulation than where shell-type brine coolers are employed. In this article we will confine ourselves to a class of troubles which are more apparent where the brine cooler is used, and yet the principles involved are applicable to any propeller circulation.

Rapidity of circulation being the great desire of all has led manufacturers to increase the size of the propellers as well as the speed at which they operate in order to accomplish this end. The shell-type brine cooler of a necessity restricts the flow of the brine and makes it imperative that the brine be forced through the tubes. These brine coolers are variously installed, but the sketches herewith show the usual arrangement in its main features. In all cases *A* being the space for the passage of the brine to the propeller; *B*, the space into which the propeller discharges the brine; *C*, the cooler itself, while *D* and *E* represent the two brine levels on either side of the propeller and form the head for the flow of the brine. This head in some instances is six inches.

As stated, the brine cooler offers some resistance to the passage of the brine, and there is the added resistance to the flow due to the passage about the cans. In describing the following troubles, it must be understood that they are not based on theoretical assumptions, but are to be found in actual practice.

Assume a system installed as shown in Fig. 1. It is desired to keep the brine level in the tank between *D* and *E*. It should be remembered that it is desirable to keep the brine level well up on the cans, for when this is not the case it is difficult to freeze the cakes solid. In the case of Fig. 1 there will be scarcely any circulation of brine about the cans, as it will simply take the path of least resistance and return to the propeller by flowing over the partition in which the propeller is located, as indicated by the arrow. This construction will work only when the level *D* is kept below the top of the partition in which the propeller is placed. In order that the brine may be kept as high as possible about the cans, the propeller is slowed down until the difference in levels *D* and *E* is small: this will help the circulation in the tank, but usually it will be so weak as to be practically valueless. In such cases as this the owners state that they get better circulation by running the propeller more slowly, which, when one first hears it, seems paradoxical: but it is true.

It is but natural to think of putting a top on the space *B* and keep the brine in, but when this is done you may have the trouble as indicated in the sketch, Fig. 2. Here *B* is closed and the brine forced through the cooler; but when it banks up to get head to overcome the resistance to its flow among the cans, it finds an easier flow back over the top of *B*, and the result as far as the tank circulation is concerned is no better than in the case of Fig. 1.

Fig. 3 shows the best way of guarding against this back-flow trouble where the space *B* is covered well above the level *D*. But even here one may have trouble unless the box *B* is carried full height tightly between the circulating partitions *F* and *G*, as shown in Fig. 4.

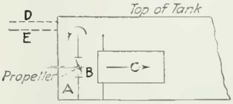

FIG. 1

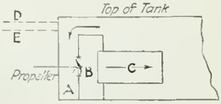

FIG. 2

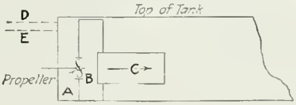

FIG. 3.

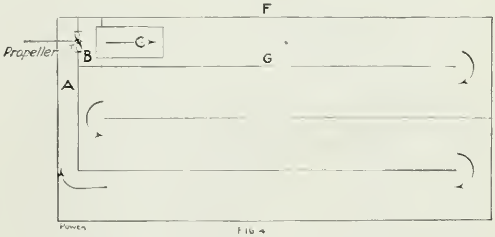

FIG. 4

Showing How the Brine Circulates

In this, as in so many of the appliances used in the process of mechanical refrigeration, it would appear that the users had not given the matter the careful consideration it deserved, but had been content with the old cut-and-try plan so evident in the early days of the industry. What is wanted now in every part that goes to make up the whole equipment is economical effectiveness.

A study of propellers as to diameter, speed, pitch, number and form of blades, etc., consideration of the circulation in the tank, how long the tank should be and of what cross-section, uniformity of flow in all parts of the tank—all would not only be interesting but productive of economical results. Such practices as herein outlined should not be allowed to continue, for brine in any ice tank should not be allowed to short-circuit.

The Double-Arch Bridge-Wall Furnace*

By Osborn Monnett†

SYNOPSIS—Arrangement and areas of furnace with a table giving the necessary dimensions for all commercial sizes of horizontal return-tubular boilers.

*

All of the necessary requirements for good combustion the No. 4 furnace supplied, but there were disadvantages about the construction. The boiler had to be set high; the single-span arch necessitated additional buck stays in the setting, and the construction was not such as could be expected to stand high temperature under heavy service. Consequently a construction which would be better adapted to the conditions was sought. Finally, a modification of the old Gulickson setting was worked out and is known as the double-arch bridge-wall furnace. Credit for this development is not claimed by the Department of Smoke Inspection; it should be given to the various contractors who installed similar settings. This development was more of an evolution representing the combined efforts of all of those engaged in the study of smoke suppression than to the efforts of any one individual.

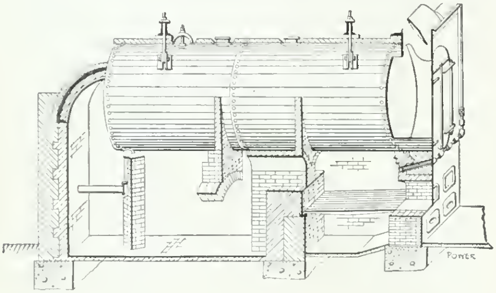

Fig. 1. Double-Arch Bridge-Wall Setting for a Two-Course Boiler

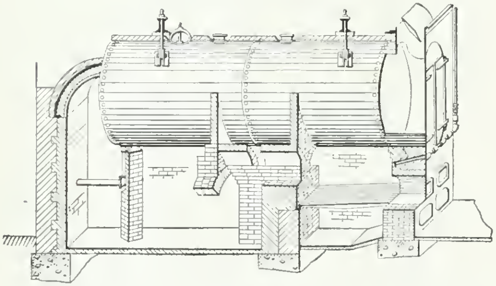

Fig. 2. Double-Arch Bridge-Wall for a Two-Course Boiler

The furnace, adapted to two-course and three-course boilers, with seams open for inspection as provided in the regulations of the Chicago Boiler Inspection Department, is shown in Figs. 1, 2 and 3. It provides an uncovered grate with siphon steam jets and panel doors through which sufficient air may be admitted over the fire, a double-arch, brick-wall construction over and back of the bridge-wall for a distance of about 4 ft., and a single-span deflection arch. With a good draft, and if carefully handled, this furnace can be run without producing dense smoke. The panels should have a free opening of 4 sq.in. for each square foot of grate surface, and should be freely used after firing, together with the steam jets.

Assuming that the average steam jet when in operation uses 10 per cent. of the total steam generated, that the fire is charged six times per hour and that the steam jets are used for 2 min. after each firing, it will be seen that the total time of steam-jet operation will be 12 min., or one-fifth of an hour. The steam used by the jets will therefore be one-fifth of 10 per cent., or 2 per cent. of the total steam generated, which cannot be considered excessive if smokeless results are a consideration.

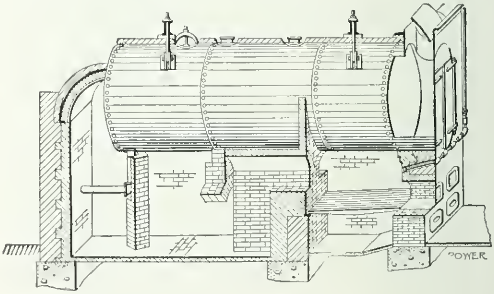

Fig. 3. Double-Arch Bridge-Wall Setting for a Three-Course Boiler

Air Admission

Many experiments have been made as to the best location for the admission of air over the fire. Some of the most common places are: Back of the bridge-wall, through the top in the front face, through the sides immediately in front, along the side walls of the furnace, over the front of the fire-doors, etc. From these experiments it has been found that the most effective location for air admission is at the dead plate. This can be explained when it is considered that the purpose of admitting air is to bring it into contact with the volatile matter. Air admitted at the dead plate naturally takes a course immediately across the fire, owing to the action of the draft, producing a scrubbing action as it were, and bringing the oxygen into intimate contact with the volatile matter coming off from the fuel. At the same time the air is being heated preparatory to entering the high-temperature zone where it is more thoroughly mixed with the hot gases, producing a secondary combustion as the gases pass under the deflection arch. This secondary combustion can be seen when looking through the rear clean-out door of such a setting.

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*Copyright, 1914, Osborn Monnett.

†Smoke inspector, city of Chicago.

DIMENSION SHEET FOR FIG. 4

(All Dimensions in Inches except Column B which is in Feet)

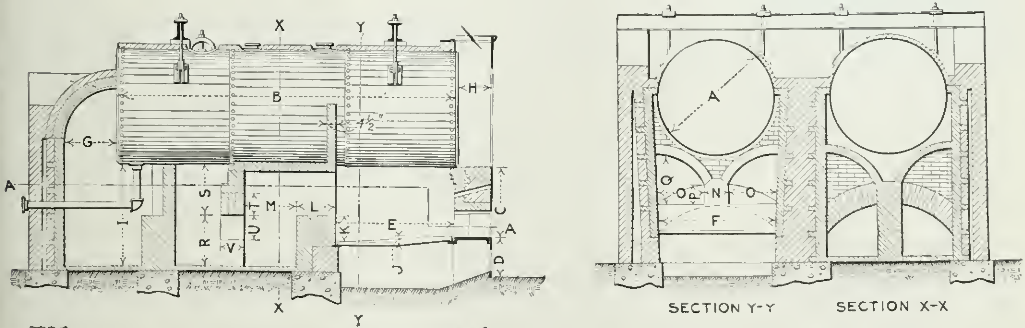
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
42	12	28	19	42	42	22	16	42½	3½	16½	18	21	9	16½	9	15	+27½	15	9	8	13½	8
42	14	28	19	48	42	22	16	44	4	15	18	24	9	16½	11	17	27	17	9	8	13½	8
48	12	30	20	42	48	24	18	45½	3½	18	18	20	9	19½	7½	15½	+30	15½	9	8	13½	8
48	14	30	20	48	48	24	18	45½	4	16½	18	24	9	19½	9½	17½	+28	17½	9	8	13½	8
48	16	30	20	54	48	24	18	49½	4½	15	18	26	9	19½	11½	19½	30	19½	9	8	13½	8
54	14	32	22	48	54	24	18	49½	4	16½	18	24	13½	20½	11½	18	+30	19½	9	9	13½	8
54	16	32	22	54	54	24	18	51½	4½	15½	18	24	13½	20½	13½	20	30	21½	9	9	13½	8
60	16	34	22	60	60	26	18	55½	5	17	22½	26	13½	23½	13	22½	33½	22	9	10	13½	8
60	18	34	22	66	60	26	18	60½	5½	15½	22½	26	13½	23½	15	24½	36½	24	9	10	13½	8
66	16	34	24	60	66	28	18	54½	5	18½	22½	28	13½	26¼	11½	22½	34	20½	9	11	13½	8
66	18	34	24	66	66	28	18	59	5½	17	22½	28	13½	26½	13½	24½	36½	22½	9	11	13½	8
72	16	36	24	66	72	30	20	59½	5½	18½	22½	30	13½	29½	11½	24½	37	22½	9	12	13½	8
72	18	36	24	72	72	30	20	64½	6	17½	22½	30	13½	29½	13½	26½	40	24½	9	12	13½	8
78	18	38	26	72	78	32	21	65	6	19	26	32	18	30	15½	27½	40	25	9	12	13½	8
78	20	38	26	78	78	32	21	70	6½	17½	26	32	18	30	17½	29½	43	27	9	12	13½	8
84	18	38	26	72	84	32	21	64	6	20	26	36	18	33	14	27½	40	24	9	12	13½	8
84	20	38	26	78	84	32	21	69	6½	18½	26	36	18	33	16	29½	43	26	9	12	13½	8

Notes:—First grade of fire brick to be used throughout with the exception of the combustion chamber floor and the side walls of the chamber back from a point one foot behind the rear face of the deflection-arch.

Fire doors must provide for special air admission of an area equal to 4 sq.in. for each square foot of grate surface

Make damper openings equal to 25 per cent. excess of tube area.

Dimensions in the above table apply only for the ordinary conditions and are subject to revision for unusual conditions.



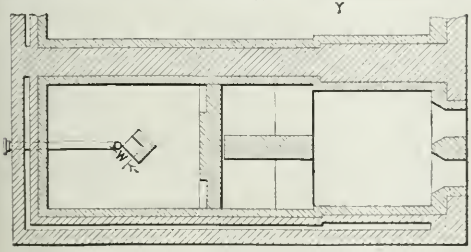


Fig. 4. Dimensions for Double-Arch Bridge-Wall Furnace for All Commercial Sizes of Boilers

Areas through Furnace

Back of the bridge-wall the setting consists of a two-span or butterfly arch. This construction stands up under the heat better than a single span, and also imposes a minimum stress on the side walls, thereby obviating the use of buck stays. One of the essentials of this setting is that proper areas be provided through the furnace. There must be a free opening of at least 25 per cent. of the grate surface at the double-arch bridge-wall; the space between the back of the bridge-wall and the deflection arch must show an area of at least 45 per cent. of the grate surface, while the area under the deflection arch should be at least 50 per cent. of the grate surface. To get this area under the deflection arch, it will frequently be found necessary to excavate in the combustion chamber, but this should be done rather than interpose a restriction at this point.

One of the fundamental principles of the setting requires that the top of the span of the deflection arch should be on a level or below the top of the bridge-wall; never above. This insures positive deflection and mixture. The combustion chamber should be paved with second-grade firebrick on edge, as the peculiarities of the furnace concentrate considerable heat on the bottom of the combustion chamber.

Fig. 4 and the accompanying table give the necessary dimensions for all commercial sizes of horizontal return-tubular boiler set with double-arch bridge-wall furnaces.

⁂

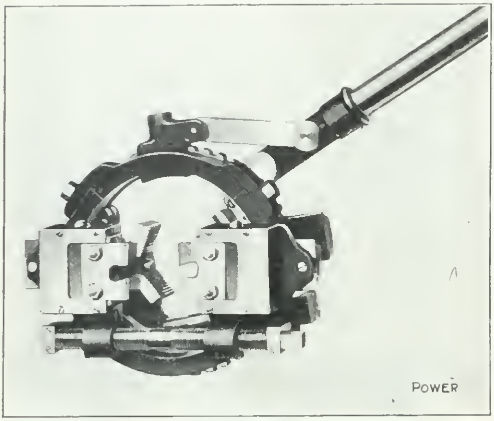
Humphrey Pumps have been selected by the Egyptian Government for the drainage of Lake Mareotis, near Alexandria. This installation will rank among the world's largest pumping stations, the complete equipment consisting of eighteen pumps each having a capacity of 100 million gallons per day through a lift of 20 feet. Each pump will be about two and one-half times the size of those installed last year at Chingford, England (See "Power", April 29, 1913), and will have an internal diameter of nearly nine feet. Gas will be furnished by nine specially designed anthracite producers. In addition, there will be installed a gas-engine lighting and power plant. Only ten of the Humphrey pumps will be installed immediately.

⁂

Duty to Contractor's Employees—An electric power company is liable for injury to a contractor's employee while at work on the company's premises, due to negligent failure to warn him against the danger of coming in contact with an uninsulated high-voltage wire, if the danger is not obvious to him, according to a recent decision of the Idaho Supreme Court announced in the case of Gagnon vs. St. Maries Light & Power Co., 141 "Pacific Reporter," 88.

Beaver Square-End Pipe Cutter

This tool cuts off pipe with a square end, without leaving any burr. The cutting knives have automatic feed.



Square-End Pipe Cutter

The cut is regulated so that a very thin section of the pipe is cut out, similar to a cutting-off tool in a lathe. instead of depressing it, leaving the pipe clean and square. The pipe cutter, manufactured by the Borden Co., Warren, Ohio, illustrated herewith, does not split the pipe and leaves the full area.

Hammond Water Meter

Every modern power station is equipped with some kind of a water meter, so that accurate and continuous records can be kept of the amount of water used in the various apparatus. Generally, the water to be metered is at a high temperature, and to meet this condition the meter illustrated herewith has been designed and placed on the market by the Alberger Pump & Condenser Co., 140 Cedar St., New York City. As shown in Figs. 1 and 2, the machine is simple in construction and its operation is easily understood. All its parts are on the outside, making it easy of inspection, and small, delicate parts have been eliminated. The meter has no valves, it is not affected by oil or mud in the water, and it will measure liquids at any temperature.

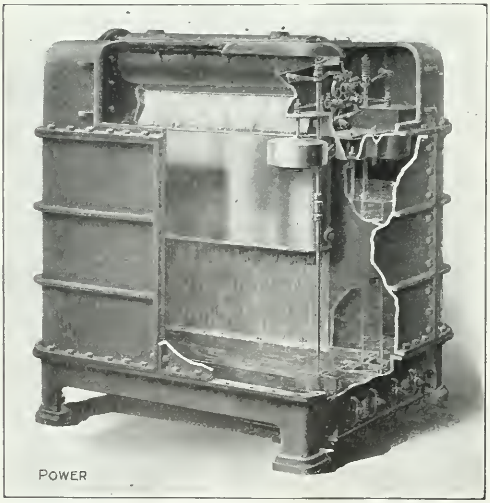


Fig. 1. Meter Showing Interior Construction

The shell is constructed of cast-iron sections, bolted together. The meter consists of two tanks, an upper receiving tank *A*, Fig. 2, in the top part of the meter, and a lower measuring tank *B*, divided into two compartments by a central vertical partition *C*.

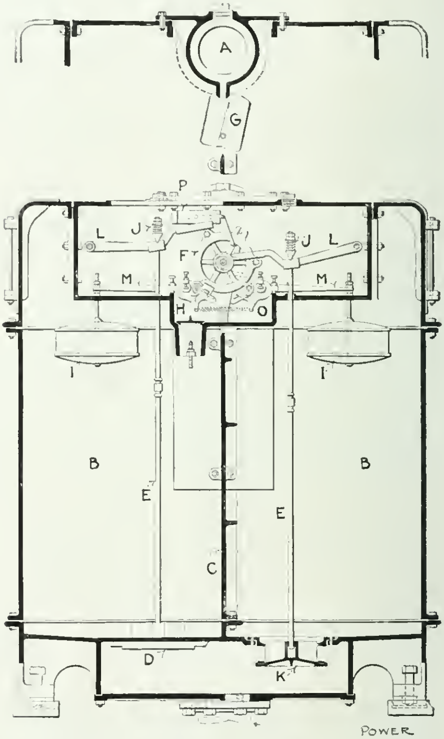


Fig. 2. Details of Meter

Liquid enters the receiving tank and flows through a slot in the bottom into the measuring tank *B*, which has a discharge valve *D* and *K* opening downward, one in each compartment. The valves are held to their seats by the valve rods *E* and are operated by the lever arms *L*. The tilting inlet valve *G* is moved by a wristplate, thereby deflecting the water either into the right or the left compartment. With the tilting valve *G* and the wristplate *F* in the positions shown, the water flowing into the left measuring tank, the operation is as follows:

The discharge valve *D* is kept to its seat by the wristplate *F*, which is held by the latch *H*. As the water rises in the compartment, it lifts the float *I*, which, through the lever *M*, unhooks the latch *H* and releases the wristplate. The weight of the water on the discharge valve *D* instantly pulls down the valve and rotates the wristplate.

This turns the tilting inlet valve G to deflect the water into the right measuring tank B; at the same time it draws up the discharge valve K to its seat, where it is held by the latch O, ready for the water now flowing into the right compartment. The springs J on the head of the valve rods E hold the discharge valves up to their seats and keep them tight.

The hardened-steel wristplate and latches have hook blocks similar to those on the valve gear of a Corliss engine. The wristplate is mounted on ball bearings, as are the rollers on the rim of the wristplate on which the levers controlling the valves roll.

The operation of the meter is automatic and continuous, and a record of the cycles of operation is registered on a revolving counter P.

The movement of the valve mechanism when the meter trips is instantaneous. A gage with a metal point is fitted on each compartment of the measuring tank with the point so set that the compartment will contain the required amount of liquid for which the machine is calibrated. The working parts are then so adjusted that at the instant the liquid closes over this point, the mechanism trips and the contents of the compartment are discharged.

The meter is guaranteed to operate within one per cent. of absolute accuracy, at any rate of flow up to its capacity, and at the temperature for which it was calibrated. It is made for capacities of 25,000 lb. of water per hour up to 300,000. The smallest size of inlet is 3 and the largest 10 inches.

Providence Centrifugal Pump

Centrifugal pumps in two styles—the double suction for generating moderate heads and the multistage for greater heads—are built by the Providence Engineering Works, Providence, R. I.

Their characteristics of design are accessibility to all wearing parts without disturbing the pipe connections, simplicity of construction and operation, easy connections to the suction and pressure mains, and a properly designed passage throughout the pump and impeller to insure an undisturbed flow of fluid. All the parts subject to wear are easily removed and renewed; they may be furnished by the manufacturer or made by the user of the pump if it is more convenient.

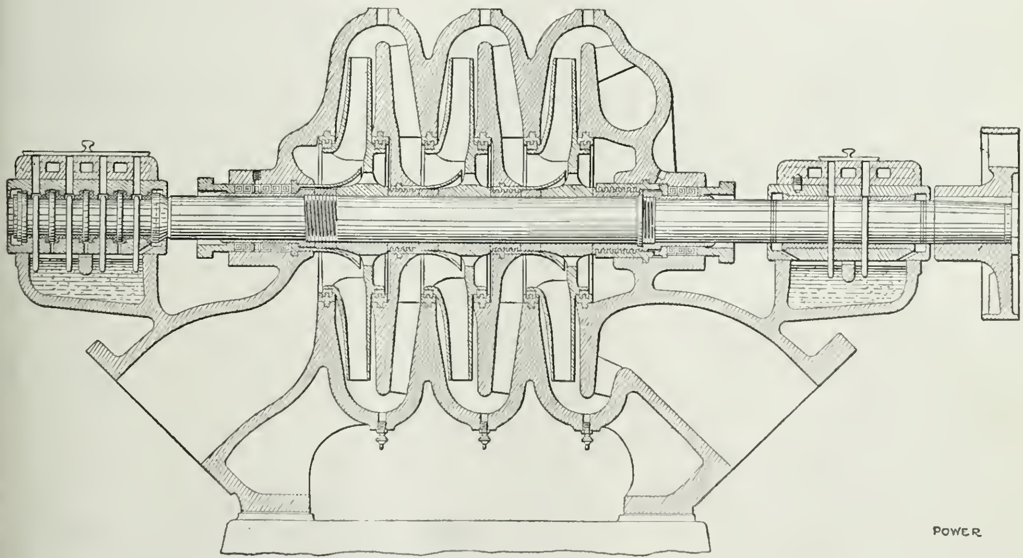


Fig. 1. Section through Multistage Pump

The pump casing is split on a plane passing through the shaft axis, so that the upper casing may be removed without disturbing any pipe connection when inspecting the pump interior. The lower casing has flange openings below the shaft for the suction- and discharge-pipe connections. This arrangement makes it easy to connect the pump and the pipes are out of the way. Fig. 2 is an exterior view of the multistage pump connected to a motor. The design of the pump is so simple that it can be stopped, opened, inspected, closed and made ready to start in less than 45 minutes.

The suction duct is so disposed as to lead the incoming current smoothly and at a uniform rate through the inlet flange and bring it in a compact mass up to the inner edges of the impeller vanes. As the liquid is protected from the rotating effect of the impeller hub, it enters undisturbed in a radial direction into the rotating-vane pas-

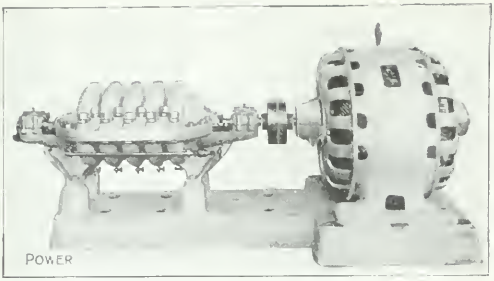


Fig. 2. Multistage Centrifugal Pump, Motor Driven

sages, where the vanes impart to it a gradually increasing degree of rotation, finally delivering it into the discharge chamber. This is one of the main features of the pump and much attention has been given to its design, so that the water must reach the impeller vanes in a compact and undisturbed state. This action will increase the pump capacity over what it would be if the liquid was disturbed by contact with the extensive surfaces of the impeller hub and web.

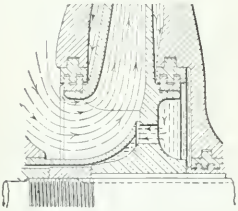


Fig. 3. Radial Impeller Labyrinth

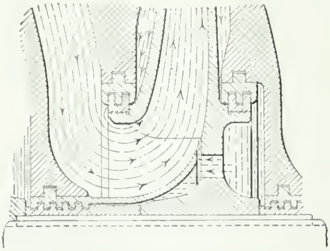


Fig. 4. Diaphragm Labyrinth

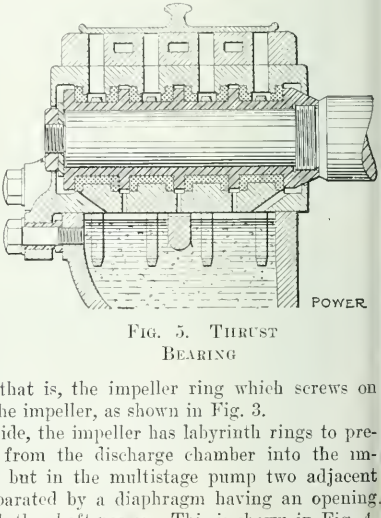


Fig. 5. Thrust Bearing

The method of protecting the incoming water from the action of the impeller hub is shown in Fig. 1, a sectional view of a multistage pump. The inlet duct terminates in a conical shell extending close to the impeller vane. This shell is of bronze, except where ammonia liquors are handled, in which case the apparatus is made of cast iron.

As shown in Fig. 1, the casing is shaped to make the travel from the periphery of the impeller through the discharge flange as direct as possible and it is proportioned to permit gradual and unhindered reduction of the jet velocity.

The two parts of the casing are bolted together with a manila paper gasket between. The gasket is shellacked to the lower casing and covered with graphite paste on the upper side, which readily allows removing the upper casing without destroying the gasket.

The impeller is of the inclosed type, in which the sides of the vanes are cast integrally. The vane passages are spaced to suit the working conditions imposed, and are hand finished; the outer sides of the hub of the impeller are machined. The impellers are made to suit the wear and corrosion according to the liquid to be handled; generally, they are made of gun metal. On each side and surrounding the inlet opening, the impeller is fitted to receive packing rings of the same material as the impeller. The impeller is keyed to the shaft and adjusted to permit its easy removal when necessary.

Leakage from the impeller chamber into the inlet chamber cannot be prevented, but it is checked by means of radial labyrinths between the inner walls of the impeller and the casing walls. This feature is shown in Fig. 1. In Fig. 3 are shown details of the radial-impeller labyrinths which are used exclusively in these pumps. They allow the slight eccentric movement of the rotating member without altering the efficiency of the joints. The lateral clearance is preserved through careful hydraulic balancing of the rotating parts and adjustment of the thrust bearings. What leakage takes place does not interfere with the incoming current and mingles with it a short distance before their common entrance into the impeller proper. The casing labyrinths are composed of rings made in halves and each is so fastened that when the pump cover is removed for inspection, the upper halves of the casing rings remain attached to the cover, thus allowing an unhindered view of the surfaces of the other parts; that is, the impeller ring which screws on each side of the impeller, as shown in Fig. 3.

On either side, the impeller has labyrinth rings to prevent leakage from the discharge chamber into the impeller intake, but in the multistage pump two adjacent pieces are separated by a diaphragm having an opening through which the shaft passes. This is shown in Fig. 4.

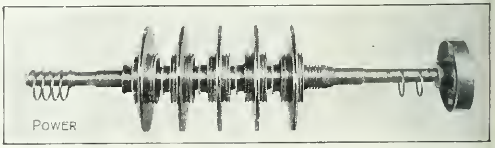


Fig. 6. Rotating Parts of the Pump

The casing shell of the radial labyrinth is split so that the upper half (it is held in the pump cover in the same manner as the impeller-casing labyrinth) is attached when the cover is removed; all the parts subject to wear are accessible for examination. The casing shell extends into the inlet chamber of the next impeller and also serves as a guide wall, thus leading the incoming liquid into the impeller passages and preventing the contact of the liquid with the rotating surfaces of the impeller web and hub. The axial clearance between the labyrinth flanges is the same as in the impeller labyrinth, while the radial clearance is sufficient to accommodate any ordinary eccentric motion of the shaft. The bronze casing, impeller and diaphragm labyrinths, for ordinary conditions, are composed of 88 parts copper, 10 parts tin and 2 parts zinc.

The bearings are in brackets cast integral with the lower part of the pump casing, one being plain and the other a combination of plain and marine thrust bearings. The plain bearing is a split cast-iron shell lined with babbitt and arranged for ring oil lubrication; it is located usually near the driving end and the other is then outboard. The bearing shell can be rebabbitted by any mechanic. The outboard, or combination bearing, known as a thrust bearing, Fig. 5, is a split, cast-iron shell, grooved and babbitted to accommodate a removable and renewable steel thrust sleeve carried by the shaft. This sleeve has thrust collars which fit babbitted grooves in the shell. Between any two adjacent collars, there is an oil ring which lubricates the plain parts of the sleeve as well as the sides of the two collars.

One end of the shell is provided with a bolt and thimble attachment whereby close adjustment of the bearing as to the thrust collar can be had and maintained. Both bearings are readily accessible for inspection by simply removing the caps and lifting the upper shells which expose the wearing surfaces of the shaft. The design of the shell is such that the upper one can be easily removed and then the lower ones may be turned around the shaft and also removed without trouble. The caps are cored out so that, in case hot liquids are handled, they can be connected to a cold-water system and the bearings thus cooled through contact of the upper bearing with the inner surface of the cap.

The shaft is protected from contact with the liquid passing through the pump by the impeller hub and locking nut. The rest of the shaft, on both sides of the impeller and that which passes through the stuffing-boxes, is protected by sleeves screwed to the shaft itself and extending past the packing. These sleeves are removable and renewable, and of material which will withstand the action of the various liquids handled. The rotating parts of the pump, Fig. 6, are balanced, first on parallels and eventually by speed trials without handling water. With the double-suction pump, both sides of the impeller are symmetrically disposed, thus an equal amount of water may traverse each side of the impeller from the suction chamber to the discharge chamber.

The hydraulic balancing of the multistage pump is obtained (a) by symmetrically disposing the impeller labyrinths on each side of each impeller; (b) by providing communication from the balancing chamber formed on the rear of each impeller through the web and into the impeller inlet proper, so as to cause the pressure to be practically the same at these two points and that the liquid traversing from one to the other does not disturb the flow of liquid entering the impeller passages; and (c) by having on the high-pressure side of the pump a labyrinth pressure-reducing device. This materially assists the operation of the packing in the stuffing-box, because the soft packing is practically under the same pressure as at the suction end. This labyrinthine device leads into a small chamber which communicates with a suction duct through a small pipe having a regulating valve. A slight adjustment of this valve suffices to counteract any imperfections in the ordinary balancing of the pump which might develop during irregular operation.

Referring to Fig. 7, it will be seen that the pump bedplate is of very light construction since ordinarily it is to be grouted onto solid foundations, the manufacturers believing that in many places the first cost may be reduced appreciably by omitting the cast-iron base and mounting the pump and its motor directly upon a concrete foundation as, except when engine driven, heavy and expensive foundations are not required. Besides, experience has shown that, no matter how heavy the bedplate may be, whenever the pump or its prime mover gets out of alignment, due mostly to stress in the piping, the bedplate is never ungrouted, but, instead, the pump is shimmed up or suitably shifted until the alignment is again obtained. This points to a possible reduction in first cost through the omission of a bedplate whenever feasible.

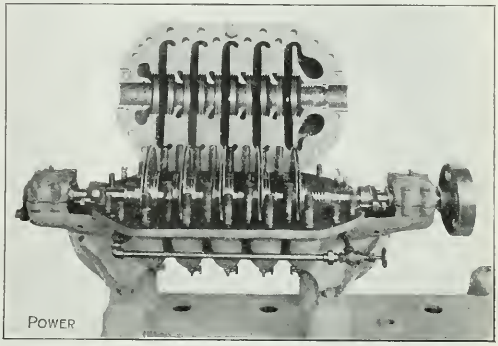


Fig. 7. Multistage Pump with Cover Lifted

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Reducing Barometric Readings to Standard Pressures

By D. O. Barrett

The accompanying table gives the pressure in pounds per square inch, also in pounds per square foot for various barometric readings from 28.5 to 30.64 in. This table is calculated, using as the density of mercury 846.8 lb. per cubic foot, the value given by Kent at a temperature of 60 deg. F.

Barometric Pressure	Lb. per Sq.In.	Lb. per Sq.Ft.
28.50	13.966	2011.2
28.60	14.015	2018.2
28.70	14.064	2025.3
28.80	14.113	2032.3
28.90	14.162	2039.4
29.00	14.211	2046.4
29.10	14.260	2053.5
29.20	14.309	2060.5
29.30	14.358	2067.6
29.40	14.407	2074.6
29.50	14.456	2081.7
29.60	14.505	2088.7
29.70	14.554	2095.8
29.80	14.603	2102.9
29.90	14.652	2110.0
30.00	14.701	2117.0
30.10	14.750	2124.1
30.20	14.799	2131.1
30.30	14.848	2138.2
30.40	14.897	2145.2
30.50	14.946	2152.3
30.60	14.995	2159.3
30.62	15.005	2160.7

Density of mercury, 846.8 lb. per cu.ft

Gas-Engine Plant for Bottle Works

In general design and construction, the new power plant of the Owens-Eastern Bottle Co., Clarksburg, W. Va., represents the latest practice in gas engineering. The fuel, natural gas, passes through the low-pressure regulator at 8 oz. and is further reduced to approximately atmospheric pressure in a special gasometer, which is between the throttle and the engine.

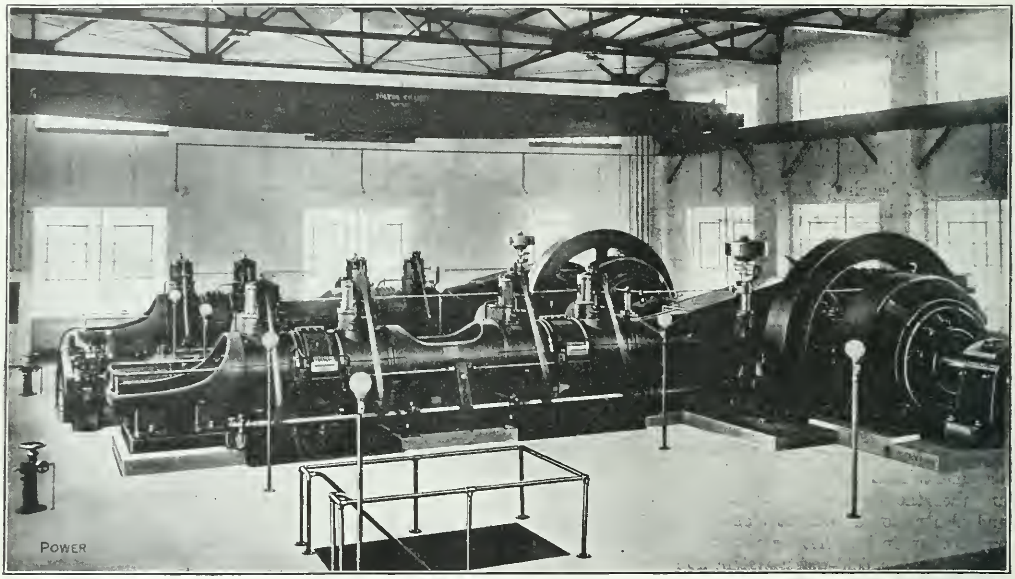


Fig. 1. Engine Room, Showing Two Units Now Installed

Each of the two main units consists of a horizontal, single-tandem, double-acting C. & G. Cooper engine directly connected to a Crocker-Wheeler direct-current generator. The cylinders are 24 in. in diameter by 36-in. stroke, and when running at 125 r.p.m., each engine develops 600 hp. A fairly constant load is carried over a continuous 24-hr. service, each unit operating alternately for two-week periods. A third unit will be installed later.

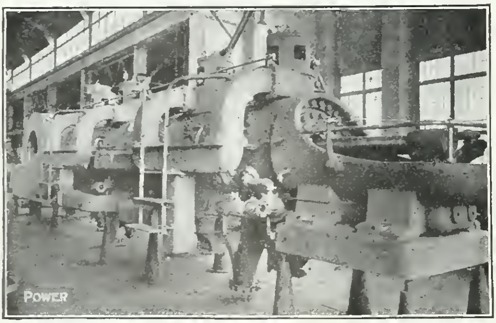


Fig. 2. Showing Piping Side of Engine

Fig. 1 is a general view of the engine room and Fig. 2 shows the piping side of one of the engines while in the erecting shop. The main layshaft carries the eccentrics operating the inlet and exhaust valves, and through a set of helical gears it also drives the small ignition layshaft, from which the igniters and special multiple force-feed cylinder lubricators are mechanically operated. The upper helical gear can be shifted longitudinally on the

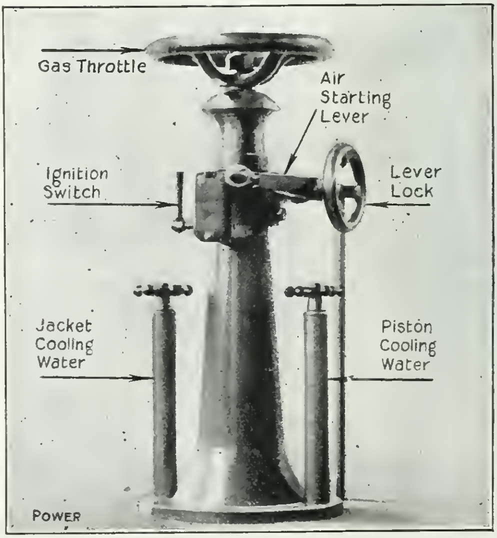


Fig. 3. Operating Stand

shaft and locked by means of a hand lever on the side of the gear case, thereby uniformly advancing or retarding all the ignition trips while the engine is running. The gas and air piping (Fig. 2), is arranged to form a stairway and platform, so that the operator may conveniently oil and inspect the inlet gear.

The simplicity of starting and stopping is also a feature, the floor-stand throttle valve or operating center being shown in Fig. 3. The gas, air starting, and water valves, as well as the ignition switch, are all on this stand. To start the engine, the compressed-air valve must first be opened, then the gas valve, and as soon as ignition takes place in the cylinders, this pressure air is replaced by the regular explosive mixture. The air-starting device is automatically thrown out of service when the air valve at the throttle is closed. Force-feed lubrication is supplied automatically to all main moving parts when the engine is started. An automatic safety stop is provided on each engine, which trips a switch in the ignition circuit should the engine speed exceed 10 per cent. above normal.

The gas consumption is about 10 cu.ft. per horsepower-hour, and the plant complete, including the building, main units, foundations and auxiliaries, will cost approximately $90 per kilowatt.

* *

Connections for Gravity Returns for Heating Boilers

By J. E. Terman

SYNOPSIS—Where two or more boilers are connected in a gravity-return, steam-heating apparatus, the method of best arranging the return connections and placing the boiler check valves is often open to discussion. The author outlines three methods, giving the objections to the first two and reasons why the last is to be preferred.

*

According to the Massachusetts rules, "the main return pipe to a heating boiler (gravity-return system) shall have a check valve and also a stop valve between the check valve and the boiler," and "when there are two connected boilers (gravity-return systems), one (1) check valve may be placed on the main return pipe and a stop valve on the branch pipe to each boiler," as shown in Fig. 1.

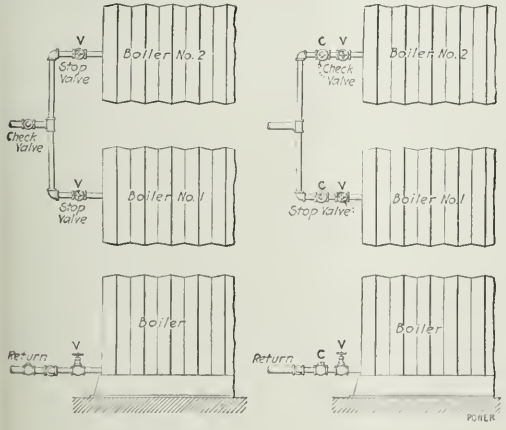


FIG. 1 FIG. 2

PLAN AND SIDE VIEWS OF CHECK-VALVE CONNECTIONS FOR RETURNS OF CONNECTED GRAVITY-RETURN BOILERS

With the arrangement shown in Fig. 1, in shutting down one of the boilers, if its steam stop valve is closed while a fire is still under the boiler, and the attendant neglects to close the return stop valve V, the continued generation of steam would build up a pressure by which the water of the boiler would be forced into the other boiler, causing the cutout boiler to be burned or cracked, if not more seriously damaged.

For meeting such conditions, the suggestion is often made that a separate check valve could be placed on each boiler, as shown at C and C in Fig. 2, but, comparing the relative safety of the two methods, there is a number of important considerations. The chances that circumstances may cause an accident with the arrangement shown in Fig. 1 are slight, for an attendant who would close the steam stop valve on the boiler which was to be cut out of use would probably also close the return stop valve.

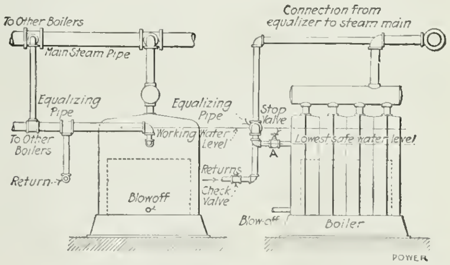


FIG. 3. END AND SIDE VIEW OF GRAVITY-RETURN CONNECTION MADE ABOVE WATER LINE OF BOILER

The objection to having a separate check valve on each boiler, as shown in Fig. 2, is the impossibility of maintaining the proper water level. With any arrangement of return connections it is difficult to secure the same frictional resistance in pipes and fittings, and with the boilers connected and operating under the same pressure, a difference of head lost in friction in the return connections results in a difference of water level.

The discrepancy of water level from this cause remains practically constant, but the use of separate check valves introduces another cause for variation. When a check valve is closed, the area exposed to pressure on the outlet is more than on the inlet side by the projected area of the valve seat, hence when the valve closes, considerably more pressure is required to open than to close it, and when opened it will not close until the total pressure on each side is almost equal—i.e., until the flow has practically ceased.

For separate checks to act in unison, they must not only be of the same size but they must be the same in areas of their seats, and at best, the alternate action of the checks results in see-sawing of the water levels—often with such wide variations from low-water line as to endanger the boilers. Sometimes the difficulty has been remedied by carefully weighting the check valves to compensate the variations, but this is only temporary, for with wear, a relative change of friction or of seating takes place and the variations of water level soon become as great as ever.

Since the difficulties from connections arranged, as in Fig. 2, are likely to arise during normal operation, it may be considered that there is less risk from an improper use of valves arranged as in Fig. 1 than from the use of a check valve on each boiler.

The serious objections to connections made as in Figs. 1 and 2 would seem to be obviated by arranging them as in Fig. 3. There, the returns are connected into the bottom of the main feed pipes, set at about the same height as the ordinary working water level of the boilers, the return connections to each boiler being provided with a return stop valve which should be closed when the boiler is idle, and a check valve should be located in the main return, as in Fig. 1. With this arrangement, if the attendant should shut off only the steam valve of a boiler while there was a tendency for the pressure to rise in that boiler, the water level could not be reduced below the level of the feed-pipe connection. No great harm could result, as the excess of pressure backing into the other boiler would probably cause a water-hammer and thereby warn the attendant of his neglecting to close the return stop valve of the idle boiler in advance of the time required for replenishing the water evaporated from the boiler continued in use.

The writer cannot testify to having tried the arrangement shown in Fig. 3, but he sees no reason why it is not feasible where two or more boilers are connected. This method of connecting the return pipe appears to be a good one for a single boiler, where there may be danger of the water level becoming reduced below the safe water line from closure of the steam stop valve.

⁂ ⁂

Relays for Controlling Electrical Apparatus

By Charles C. Raitt.

SYNOPSIS—An explanation of the operation of protective relays of the simple overload reverse-current, definite time-limit and inverse time-limit types; also relays for remote control of motors, switches, etc.

⁂

In its various forms the electromagnet is the most common means of producing the motion necessary for the automatic control of electrical apparatus. Among its principal applications are protective relays, controllers for elevator motors, large machine-tool motors and hand-operated relays for controlling distant apparatus.

Protective Relays

Protective relays are divided into classes according to the nature of the protection desired, these being: simple overload relays, reverse-current relays, definite time-limit relays for overload protection, inverse time-limit overload relays, and combinations of these. In general, it may be said that "make-contact" devices are used for protective relays when a reliable source of direct current is available, and "break-contact" devices when this is not the case.

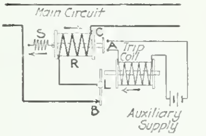


Fig. 1. Simple Overload Relay for Direct Current

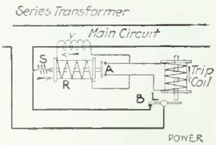


Fig. 2. Simple Overload Relay for Alternating Current

There are two general types of simple overload relays in common use. If an auxiliary source of current is to be used for operating the tripping mechanism, a single coil relay may be placed in series with the main circuit and arranged to close the trip coil circuit when overload occurs, as shown diagrammatically in Fig. 1. The tension in the spring *S* is regulated according to the maximum value of current desired in the main power circuit. When this value is exceeded, the magnetic pull in the series relay *R* overcomes the force of the spring and causes the contact *C* to close the trip coil circuit at *A*. The tripping relay, in turn, presses on the lever *L* and opens the main circuit at *B*. This combination may be used for either alternating current or direct current. Often, as in the case of switchboard circuit-breakers, the auxiliary circuit is dispensed with entirely and the series relay is made to open the circuit directly.

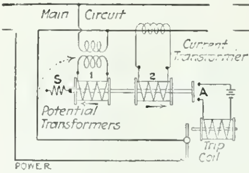


Fig. 3. Showing Overload Action

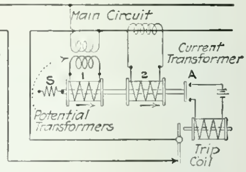


Fig. 4. Showing Reverse-Current Action

For alternating-current circuits an alternative method may be used when there is no direct-current supply available; this is shown in Fig. 2. Here a series transformer is placed in the main circuit and two parallel circuits are taken from its secondary winding. To the first of these circuits a relay *R* is connected, which normally short-circuits the second circuit, which is used for energizing the trip coil. When an overload occurs, the pull in *R* overcomes the force of the spring *S* and opens the short-circuiting switch at *A*. Current then passes from the transformer through the trip coil, causing the latter to press on the lever *L* and open the main circuit at *B*.

For circuits which require protection against continued overload, but in which it is important to maintain service, the possibility of interruption of service due to momentary overloads is avoided by using the time-limit overload relay. The function of this is to delay the opening of the circuit until any momentary overload may have had time to die out. If the overload continues, however, the circuit will be opened. There are two types of time-limit relays, the definite and the inverse time-limit relays.

The definite time-limit relay is commonly composed of a plunger magnet, a spring and a bellows. When overload occurs, the plunger moves through its complete path instantly, compressing the spring. The spring is in contact with the bellows, and the time required to compress the bellows is proportional only to the strength of the spring and is independent of the magnitude of the overload. Thus the time required to compress the bellows is always the same. The tripping mechanism is so arranged that the circuit will not be opened until the bellows is completely compressed.

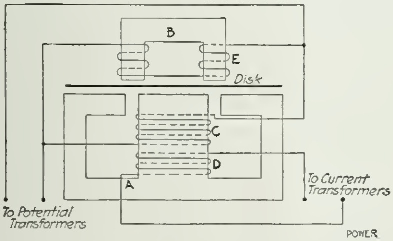


Fig. 5. Integrating Wattmeter Type of Reverse-Current, Time-Limit Relay

The inverse time-limit overload relay may be constructed similarly to the definite time-limit relay, except that the spring is omitted. The plunger acts directly upon the bellows, and for this reason the time required to compress the bellows is now inversely proportional to the magnitude of the overload.

The time-limit action in these relays may be obtained in other ways, as, for instance, by substituting air or oil dashpots or the action of gravity for the bellows.

Reverse-Current Relays

Another type of direct-current, inverse time-limit relay is in common use for the protection of storage batteries and rotary converters against reversal of current. It is composed of a stationary coil and a rotating coil wound on an aluminum frame. The main feature of this relay is its reverse-current action. It gives no overload protection when the current is in the positive direction, but when the current in the circuit reverses, it causes the rotating coil to reverse. This reversal is opposed by eddy currents set up in the aluminum frame, which react against the flux in the moving coil and give the required inverse time-limit element. The trip coil contacts are so arranged as to operate the circuit-breaker when the rotating coil reverses.

Figs. 3 and 4 show an ingenious method of producing an alternating-current overload, reverse-current, inverse time-limit relay for single-phase operation. There are two coils wound on the same relay and so connected as to oppose each other under normal conditions. One coil is excited from a current transformer in the main circuit and the other from a potential transformer in the same circuit. Normally, the pull of the spring *S* and the coil 1 are sufficient to overcome the action of the coil 2. When overload occurs, the strength of coil 2 is increased, while that of coil 1 is unchanged. Therefore, the plunger moves to the right, closing the trip-coil circuit at *A*, which in turn opens the main circuit at *B*.

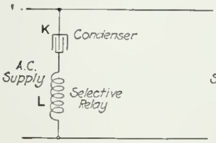


Fig. 6. Selective Control Relay for Direct Current

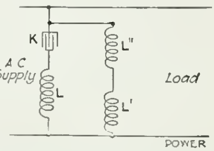


Fig. 7. Selective Control Relay for Alternating Current

If the line in which the relay is placed is operated in parallel with some other line and failure occurs between the relay and the generator, current will be fed back through the relay into the failure. In this case the current in coil 1 will be reversed, while that in coil 2 remains unchanged in direction, with the result that the two coils will combine to oppose the force of the spring *S* and operate the circuit-breaker. This relay is defective in that it is inoperative at the low power factor which obtains when there is a short-circuit on the line.

Still another common type of alternating-current overload, reverse-current, inverse time-limit relay is of the integrating wattmeter type, the essential features of which are shown in Fig. 5. As with the integrating wattmeter, there are permanent magnets above and below the rotating disk on one side and electro-magnets occupying the same position on the other side. The permanent magnets are not shown in Fig. 5. Whenever the torque in the disk becomes greater than that for which the relay is set the trip coil contacts are closed. The coils *E* and *C* are in parallel and *D* normally opposes them.

In case of overload, the strength of the coil *D* is increased, and this in turn increases the torque in the disk and opens the circuit. When the voltage drops, the coil *C* acts as a secondary for *D* and sends current through the coil *E*, this action again increasing the torque in the disk and opening the circuit. If failure occurs and current is fed back through the line, the current in *E* and *C* will be reversed and will combine with *D* to produce an excessive torque in the disk. The relay will act under all abnormal conditions.

Controllers

Controllers for elevators, large machine tools and such apparatus are usually of simple design, consisting of series of contactors, each of which not only performs its primary function, but also controls the circuit which energizes the coil of the next contactor in the series. The primary functions of the contactors are determined by the requirements of the apparatus to be controlled, as, for instance, the cutting out of resistance, step by step, in starting a motor. The combining of contactors to produce a given result may become extremely involved, but the relays themselves are usually simple plunger or traction magnets, placed in series with the circuit to be controlled.

Hand-operated relays for controlling distant apparatus consist of control relays, operated by light currents, which in turn energize the plunger magnets, or start the motors which move the switching devices for power circuits. It has been customary up to the present to provide separate circuits for the control currents.

Recently, however, three Englishmen, W. Duddell, A. H. Dykes and H. W. Handcock, have succeeded in superimposing a control current on the main power lines, thus enabling them to control distant apparatus from a central point. The control current used is of high-frequency and low-voltage, and the effect which it produces on the main current is negligible.

Fig. 6 shows that with direct-current transmission lines, a selective relay on which the control current will act, but which will not be affected by the power current, is a simple arrangement. Of course, this is because direct current will not pass through the condenser.

With an alternating-current supply, the problem is not so simple. In Fig. 7, K is also a condenser, L is one of the relay coils, and L' another having the same number of turns, and wound on top of L'; L'' is a choke coil. The low-frequency current passes through the condenser K and is given a lead of 90 deg.; the other branch of the same current passes through L'' and is given a lag of 90 deg. The result is that the two branches cancel each other when they pass through L and L', respectively. The high-frequency ripple current passes the condenser, but will not pass the choke coil, therefore it is left to operate the relay.

Will Quizz, Jr.

SYNOPSIS—Will does not have a clear notion in regard to latent heat, total heat, etc., and takes advantage of his first opportunity to ask Chief Teller about them.

⁂

"Chief, what is this latent heat thing, and what is it like? And there's sensible heat, and B.t.u.'s and other things in the steam tables. I would like to get acquainted with the whole lot."

"Hold on, Will, don't go so fast. You can't get all of them in a job lot."

"Well, then, introduce me to some of them, anyway."

"To begin with, take the British thermal unit. That is its full name, but it usually goes by the initials B.t.u.

"In order to measure or weigh anything, we must first have a standard unit for that purpose, a pound or a foot, etc. In the same manner, in order to measure heat it is necessary to have a unit for its measurement. It is the amount of heat necessary to change 1 lb. of water 1 deg. in temperature. Water is used as the means to establish this unit because it is the most convenient at hand.

"Water does not change 1 deg. with the application of the same amount of heat at all points from 32 to 212, because water varies in density at different temperatures. For a long time a B.t.u. was specified as the amount of heat required to raise 1 lb. of water 1 deg. at the temperature of its maximum density (about 40 deg. F.). Later, it was decided that the fair basis would be the *average* amount of heat required to raise 1 lb. of water 1 deg. between 32 and 212, so in the Marks and Davis steam tables the B.t.u. is taken as $^1/_{180}$ (because 212 — 32 = 180) of the total heat required to raise water from 32 to 212 deg.

"*The sensible heat* is that heat which is absorbed by any substance in changing from one temperature to another without change of form. Any change of temperature without changing the physical condition of a substance, either liquid or solid, is called sensible heat. When heat is added which changes its physical condition from one state to another (for instance, changing water into steam), the sensible heat does not change during the process, but we know by reason of the continued application of heat to the substance that B.t.u. are being absorbed. This is called *latent heat,* because it does not appear in the form of changed temperature.

"*Latent heat* is the heat required to produce change of form or state without change of temperature.

"*Latent heat of steam* is the heat required to convert 1 lb. of water into steam under the same conditions of temperature and pressure.

"Now, the next question is, how many B.t.u. are necessary to convert a pound of water into steam at the same temperature? We have seen that it requires 180 B.t.u. to bring the water from 32 to 212 deg. Careful experiments by Regnault, about 1845, and others later, determined how many B.t.u. were used up in the process of evaporating a pound of water from and at 212 deg. and it has been established that, in an open vessel at about the sea level (or under 14.7 lb. absolute pressure), 970.4 B.t.u. are necessary.

"*The total heat* is all of the heat in the steam above 32 deg., or all the heat that would be required to raise water from 32 deg. to the boiling point (212 deg.), and then to convert it into steam. It is the sum of the *sensible* and *latent* heat.

"One pound of steam at 212 deg., and at atmospheric pressure, contains 1150.4 B.t.u. In other words, the 180 B.t.u. sensible heat and 970.4 B.t.u. latent heat equal 1150.4 B.tu. total heat.

"A good way to keep these things in mind is to think of a certain *quantity* of heat put into water to bring it to the boiling point (212 deg.)—which is sensible heat; then another *quantity* of heat required to evaporate the water into steam called latent heat of evaporation. Then, after all has been turned into steam, if more heat is applied, the steam becomes superheated and shows a higher temperature, which is sensible heat again.

"Well, Will, by this time you ought to feel somewhat acquainted with these members of the thermal family. Next time we get together we will discuss how this thermal family is related to mechanical energy."

Holding Strength of Stay-Bolts

By J. C. McCabe

A Scotch boiler which failed at the rear stay sheet by stripping all the stay-bolts, showed bulges between the stays of varying extent up to one-half an inch in some places. It was quite apparent that this bulging had been progressive and that the ends of the stay-bolts had been hammered up repeatedly to stop leakages. The plate was ½ in. thick and was stayed with 1⅛-in. bolts pitched 7¼x7¼-in. centers. The safety valve was set at 105 lb. The plate should have given good service and longevity under that pressure if reasonable care had been taken to keep its surfaces clean.

Later several tests were made to determine the holding strength of stay-bolts in flat surfaces under normal conditions and in plates that were bulged, the stays in some cases having heads and in others without them. Following are the conditions and results obtained:

Stay-Bolt and Plate No. 1—This stay-bolt was 1⅛ in. diameter, with 12 threads per inch. The end, headed over in the customary manner, had a diameter of head of 1⅜ in. and a depth of ⅛ in. The material was regular stay-bolt stock. The plate was flat and the bolt fitted in the usual manner. This stay-bolt is of the same size as used in the boiler which failed. The following data are explanatory:

External diameter of stay, in.	1⅛
Diameter at bottom thread, in.	0.9807
Area section at bottom thread, in.	0.755
Pitch of stay-bolts, in.	7¼
Net area of stayed section, sq.in.	51.707

In the destruction test this stay-bolt reached the yield point at 29,100 lb. and failed by stripping the head when the load reached 46,140 lb., because of reduced diameter. The low-yield point was, no doubt, due to the yield on the threads. The pressure equal to the yield-point strain would be 564 lb. gage, and the gage pressure to cause ultimate destruction, as shown by the test, was 893 lb.

Stay-Bolt and Plate No. 2—This test was made to determine the comparative strength of a stay-bolt, without a head and in a buckled plate, with the same character of bolt and plate in first-class condition, as in test No. 1.

In test No. 2 the stay-bolt was of the same stock and size and made at the same time as No. 1. The plate was from the same piece as No. 1, but it had been dished about three-eighths of an inch, thereby enlarging the stay-bolt hole on one side. Under the test the bolt stripped at 24,800 lb., which gave an equivalent of about 483 lb. gage pressure.

The failure occurred under less strain than the yield point of No. 1, which was 564 lb. gage, and the ultimate strength was only about 54 per cent.

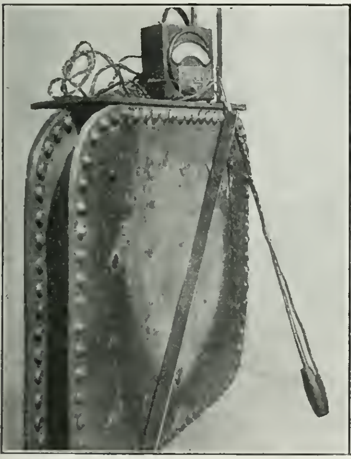


Fig. 1. Heated Plates with Bolts Headed Up

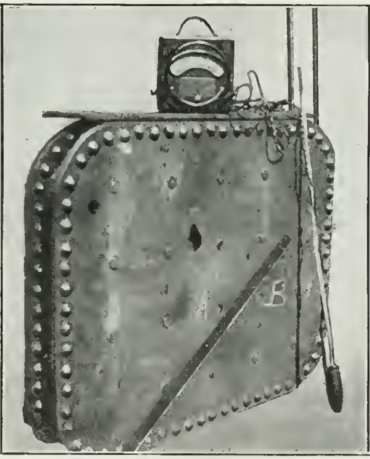


Fig. 2. Bolt *B* Had No Head

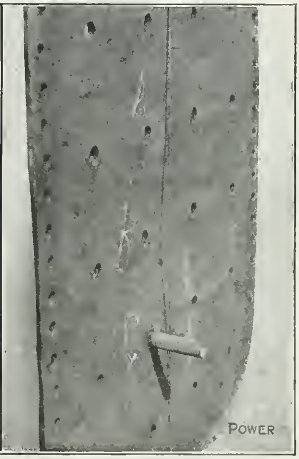


Fig. 3. Effect on the Thread from Bulging

Stay-Bolt and Plate No. 3—In this test a stay-bolt similar to Nos. 1 and 2 was used and headed over in the regulation way. The threads began to yield at 26,000 lb. and finally failed at 28,800. This gave a pressure of 522 lb. at the point where the threads began to yield, and 557 lb. at the limit.

This comparison of the three tests is self-explanatory:

	Ultimate Strength, Lb.
Test No. 1—Regular head, straight plate	893
Test No. 2—No head, plate buckled ⅜ in.	483
Test No. 3—Regular head, plate buckled ⅜ in.	557

Stay-Bolt No. 2, Test No. 4—This stay-bolt had about ½ in. cut from its end after the test with a dished plate; it failed at 21,800 lb. It was then screwed into a new plate prepared like the defective boiler, with a buckle of ⅜ in. The end of the stay was screwed through and was flush with the plate. On the testing machine the stay stripped at 10,200 lb., which was about the same as a gage pressure of 196 lb. The value of the stay-bolt head is clearly indicated.

For the purpose of determining the behavior of a flat stayed surface under varying conditions of heat and pressure, a steel ring was made up with a plate 0.447 in. thick on one side, having a yield point of 42,846 lb. (see laboratory report), and a plate 0.517 in. thick on the other side. The spacing of the stay-bolts was 7¼x7¼ in.

To determine the ultimate elastic strength of this plate, a hydrostatic pressure was applied, but before subjecting to pressure a straight-edge was applied to the 0.447 in. sheet, which disclosed that it was flat and true, except at the outside of the outer row of stays, leaving the central portion slightly prominent.

Under a pressure of 370 lb. a bulging between $\frac{1}{16}$ and ⅛ in. was noted, which disappeared on release of the pressure. The pressure was again applied, to 400 lb. gage, and on release a set of 0.02 in. was noted. The third time, the pressure was applied to 455 lb., and on release a set of ¼ in. was found between the stays.

The United States Bureau of Steam Engineering formula to ascertain the elastic strength as applied to this case is

$$\frac{42.846 \times 0.447^2}{(7.25 - 1.375)^2} \times 1\tfrac{1}{2} = 372\ lb.$$

The actual bulging pressure was between 372 and 400 lb., when a set of 0.02 in. was found.

In order to observe the effect of heat on a flat stayed surface similar in design to the defective boiler, an air pressure of 95 lb. was maintained on the sample and a flame was made to impinge against the surface. The plate, 0.447 in. thick, took a set at 1075 deg. F., Fig. 1, and the 0.517-in. plate took a set at 1275 deg. F.

Stay-Bolt B, Fig. 2—This stay was used in the test sample of stayed surface and stripped on threads at 95 lb. internal pressure at 800 deg. The inside threads showed that at the time of failure they had but small contact. This stay had its head cut off before the test.

Stay-Bolt A, Fig. 2—This stay-bolt was used in the test sample and it stripped under 95 lb. internal pressure, with a full head, when the plate was at 1275 deg. The greater bulging can be seen at *A*, Fig. 3.

The significance of this bulging is that the limit of elastic strength is about one-half the ultimate strength, and, at 98 lb. or thereabout, the stay would be on the balance as to strength of its threads (conditions considered), and any disturbance with a boiler pressure of 95 lb. would tend to disaster.

A vital factor in this problem lies in the destructive stresses induced in the stay-bolts by overheating the stay-plate and in the destructive movement on the threads. At times this plate had an expansion of about ⅝ in., and the effect was cumulative from the bottom toward the top. The sheet is held to the shell at the bottom by stays, but is free to expand upward.

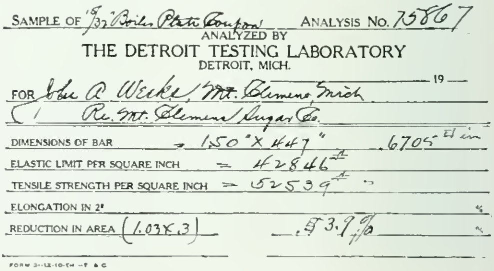
As soon as bulging occurs between stays in a flat surface, a compression of the plate on the outer end of the stay-bolt occurs, while the plate draws away from the bolt on the inside. This greatly reduces the holding strength of the stay, so that often boilers are found in operation that are at the point of failure.

In dealing with flat surfaces where plates are buckled, new stays should be installed immediately and care should be taken that they have a substantial head, well formed, or, preferably, the stays should be made with a tapered thread for insertion from the fire side of the plate into a hole suitably threaded for the bolt. This would enable the boiler maker to fill the threaded hole solidly before heading the bolt over. The present methods are somewhat lax, owing to the desire to speed up on construction.

Fig. 3 shows the inside of the plate after the foregoing test. Stay-bolt holes at *A* and *B* are for the same stays as in Fig. 2. Stay-bolt *C* shows the effect of the bulging between stays.

Samples of what was once an excellent quality of firebox steel disclosed that it was unsafe for use in a boiler because of destructive internal strains caused by forming up the plates.

It would seem that the time is at hand for a radical departure in boiler-shop and plate-mill methods and for a great reduction effected in boiler failures. It is misleading to depend on increased factors of safety only when the very methods of manufacture tend to strain the materials far beyond the elastic limit in the initial steps of the shop work. In the case of a horizontal-tubular boiler made from ½-in. plate and rolled up cold in the ordinary manner, the outer surface will elongate over 1½ in., while the inner surface will shorten about the same amount. We thus produce a change in the entire plate, because the outer half is under a tension strain and the inner half is under a compression load. Assuming that the courses of a 72-in. boiler are uniform in strength throughout its circumference and it is formed without the strains referred to, it would require an internal pressure of over 600 lb. to induce metal changes equal in extent to that produced by rolling; the limit of strength would be upward of 800 lb., and the working pressure upward of 160 lb.


SAMPLE OF 9/32" Boiler Plate Coupon ANALYSIS No. 75867
ANALYZED BY
THE DETROIT TESTING LABORATORY
DETROIT, MICH.
19
FOR John A. Weeks, Mt. Clemens Mich
(1 Re. Mt. Clemens Sugar Co.
DIMENSIONS OF BAR = 1.50" X .447" .6705 □ in
ELASTIC LIMIT PER SQUARE INCH = 42846 #
TENSILE STRENGTH PER SQUARE INCH = 52539 #
ELONGATION IN 2" %
REDUCTION IN AREA (1.03 X .3) 53.9% %
FORM 3-12-10-TH

Reproduction of Laboratory Report Card

Does it not seem peculiar that boiler materials must be strained to a destructive point before even assembling them. Increasing the factor of safety is in a measure nullified by the increased change in metal necessary on account of rolling thicker plates and the possibilities due to the segregated metaloids.

It is the writer's opinion that the time is not far distant when the rolling mills will furnish boiler sections rolled to the desired diameter and thickness, at a price less than the present cost of plate and shop work.

⁂

A 40,000-Hp. Steam Turbine has recently been completed in the shops of Brown, Boveri & Co., Mannheim, for the Mark Communal Electricity Works Co., of Hagen. It is designed to use steam at 50° C. (662° F.), and 12½ atmospheres (184 lb.) pressure, which means 287 Fahrenheit degrees of superheat. The speed is 1000 r.p.m., and the generator produces three-phase current at 11,000 volts and 50 cycles. The length of the set is 16 m. (52.5 ft.), and the width 4.2 m. (13.8 ft.), the total weight being 385 tons with condensing plant.

Editorials

Industrial Education and the Engineer

Circumstances are increasing the necessity for training men for the activities of life at the expense of the public. The changes which have come about through the introduction of the factory system of manufacture, where an operative tends only one machine, and where it is neither possible nor profitable for a shop to train its own skilled mechanics except by establishing a school within its own shop, all have had a vital bearing on this question.

This particular influence has no great bearing on the training of young engineers. A man in the power plant is valuable, not for his ability to do some one thing quickly and well but for his ability to do many things well and to think his way through troubles before they reach him. He must cross his bridges before he comes to them, even if he has to shatter a time-worn proverb to do it. From this one fact it is evident that the problem of industrial education for the power-plant operator is different from that for the machinist or the cabinet maker. A machinist who is dexterous, can get along even on a job that he had never done before. Although when properly trained he should be an all-around machinist, the man who learns to do only one or two things well has a place in life and may earn a fair living. A power-plant man whose abilities were marked along only one line would be hard put to it to find a job at all, much more to find one that paid well. Even if employers might risk hiring him, state laws step in and insist that he shall have a fairly good all-around development. This is likely to increase rather than diminish as the complexity of the work increases.

Twenty-five years ago, a power plant consisted of a boiler running at a low pressure, an engine operating under what we would call easy conditions today, and a pair of pumps, possibly a condenser, and surely a gravity-return exhaust steam-heating system. A boy who had fired for a time, and who was bright enough to become familiar with the simple piping layout, could be trusted to keep up steam and keep the engine turning over. Fortunately, there was never a machine that would stand more abuse than a slide-valve engine and still keep going if supplied with enough steam.

Now, that is all changed. Except for sawmill engines, where it is cheaper to burn sawdust under the boiler than to dispose of it any other way, it is necessary to make every pound of coal produce results. The engine speed must be just right, particularly if it is directly connected to an alternator and is one of a number that must keep step. The transmission lines, the lighting lines, the motors and transformers, a vacuum-heating system and a thousand and one things that our fathers never had to worry about, are all present, not merely in isolated places, but in almost every plant even of small size. This means that an engineer now must possess considerable technical knowledge. Dexterity has sunk to comparatively small importance.

It might be guessed from this that, to be an engineer, one should be a graduate of a technical school. Few technical graduates want such jobs at all; their education leads away from positions requiring the restraints that an engineer must practice. The work does not attract them because there is too much additional training ahead before they can get and hold a responsible position, in spite of the considerable study of power and transmission subjects in school. The work given is so universally approached from its theoretical aspects rather than from its practical ones that it is necessary for the graduates to begin all over from the other side of the question. This comes about in turn through available textbooks. In any small college, it is perfectly possible for anyone with a good general education and a textbook to teach steamwork at short notice. If he is an operating engineer, he may start out with the determination that he will teach it as it is and let the textbooks slide, but he soon finds that the head of the department or the president can only think in terms of textbooks, and as that is the line of least resistance, he follows it. Probably, if he persisted in doing what he knows is right, there would be a vacancy the next year, so he cannot be much blamed.

If engineers cannot be trained in technical schools, where should they be trained? Practice in one plant is not enough today. There are no two plants alike. No one without a knowledge of fundamental principles can shift from one to another without embarrassment, which may mean serious injury to the plant. The teaching of fundamental principles is an educational proposition. We are also coming to feel that training in the practice of a trade is also a school job. Since the technical schools have undertaken another part of the world's educational work, it will be necessary to establish new schools if this work is to be done in them. This has already been attempted in a small way. There are seven states which have by law made it possible that trade schools should be established by cities and aided by the states themselves. Massachusetts has taken the lead in this form of education and the account of the work there being undertaken as given by E. H. Fish, on page 153, will be found to present a serious problem, well deserving attention and discussion.

Important Court Decision

The recent court decision in the case of Percival vs. the New York Edison Co. (see page 153) has far greater significance than its bearing on the particular case involved, for, if the decision stands, it will invalidate the clause in the present contracts which stipulates that no other electric service shall be introduced or used without the consent of the Edison Co. This clause, sanctioned by the Public Service Commission, has proved an effective weapon against the block plant and its elimination would probably result in greater use of this system, which, under many conditions, is admittedly the most economical method of electrical supply.

In the case at hand, there were two adjoining buildings, one having a plant with sufficient excess capacity to supply the second building, thereby raising the load factor and reducing the cost of generating electricity. This made it possible for the management to sell to its neighbor at a lower rate than the latter could buy from the Edison Co. Conditions were such, however, as to make it desirable to use this service during the day and Edison breakdown service at night.

The Edison Co., in refusing to supply the service, claimed that the private plant was a competitor and that it should not be compelled to furnish breakdown service for a competitor; this contention was upheld by the Public Service Commission. Had the case been advanced on the grounds that the service demanded was for a peak-load period, a special rate might have been justified; instead, the contention was that the consumer must take all his energy from the Edison Co. or go without it.

In reversing the opinion of the Commission, the court held that the clause under discussion was an arbitrary attempt on the part of the company to establish a monopoly and was in no way a regulation with respect to the service. It further maintained that the Edison Co., in lieu of the privileges granted by the city, especially the use of the public highways, is bound to serve impartially every member of the community who demands service, providing, of course, that the mains are within a reasonable distance of the applicant's premises.

In the light of this ruling, the private plant could hardly be treated as a competitor of the central station, as it does not receive any special privileges from the city and does not use the public streets, the supplying of electricity to the adjacent building being merely a business transaction between two private individuals on their own premises.

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The New Table of Contents

All but our very new subscribers know that for many years and until the first of this year, certain of the reading matter in Power was grouped in departments, namely, Electrical, Gas-Power, Heating and Ventilating and Refrigeration. For greater convenience in making up the paper, and to enable a better selection without the restrictions the old practice imposed, the department arrangement was abandoned at the beginning of the last volume (Vol. 39).

The only serious objection to the change was that it was no longer so easy to pick out the matter in which one may be especially interested. To remove this fault, we have modified the manner of presenting the table of contents on the first page inside of the cover, and beginning with this issue the contents will be classified not only in the former departments, but with still greater subdivision into such general heads as seem appropriate.

Instead of being classified under "Correspondence," the letters, although still printed all together, will be indexed like any other short articles. As before the more important articles will be summarized.

We shall be glad to entertain criticisms and suggestions regarding the new arrangement with a view to further improving it. The readers can tell better than we can what they do find or would find most convenient.

Individual Stacks

That one-stack-to-a-boiler idea in the Moline plant (described on pages 118-124) is a matter of interest for its unusualness, if nothing else. Almost nowhere but on a rolling mill or steel works can such a "forest of stacks," as it is aptly called, be found. While, similarly as the sectional bookcase, the individual chimney may facilitate extensions of the equipment and there may be other advantages, as mentioned in the article, it probably would not be safe to commend it as the best practice. This plant is already contemplating the substitution of four stacks of equivalent area when any further accessions are made to the boiler plant. Just as group drive proved the compromise between one motor to the shop and one motor to each tool, it will be found that one stack to a certain number of boilers or about a certain boiler horsepower will be the happy medium between the single monstrous chimney and one for each boiler.

⁂

So called waste material is in reality good material in the wrong place.

⁂

The index of Power for the first half of 1914, Volume 39, is now ready. Copies will be sent, without charge, upon request in writing.

⁂

Ailments of the power plant are sometimes dealt with by the auto-suggestion method or by absent treatment, but the best results are usually obtained by the laying on of hands with the proper zeal and mental condition.

⁂

The cartoon this week, while mainly intended to amuse, typifies feelings many of us have had, one time or another. If we could, we would throw the poor coal back on the company that sold it to us. Those of us who buy our coal on specification can come pretty near following out the example of the picture, figuratively.

⁂

Professor Olaf Heggstad, in a recent lecture, said that the rights of the Rjukanfos, which by next year will be able to produce more than 250,000 horsepower, were sold in 1890 for £55 10s. In making up the charges to the consumer, will interest and profit be asked for on this amount or on a bloated estimate of the present value of the franchise?

⁂

A large number of inquiries are received by this paper weekly, some of which are of a general nature and can be answered with a few words on our "Inquiries of General Interest" page. Others deal with special and individual questions which would not interest the readers in general; these are answered by mail when they are not too involved, for we cannot furnish a consulting engineering service for two dollars a year. There is still another class, whose answers would require more space than can be allowed on the inquiries page and would moreover, admit of differences of opinion. These we intend to print from time to time for the discussion of our readers. It will often be impossible to print all the answers, but in deciding which shall be printed, the character of the discussion and the date of its receipt will be governing considerations.

Correspondence

Trouble in Starting Gas Engine

Trouble was experienced in starting a 600-hp., four-cylinder, four-stroke-cycle gas engine running on natural gas. It had been down for repairs over Sunday and an attempt was made to start on Monday morning with three cylinders, the fourth, which was out of commission, happening to be one of the air cylinders, thus leaving one air and two working cylinders for starting.

After several unsuccessful attempts, it was thought that the trouble was with the gas. The gas valves were reset and the admission and exhaust valves examined and found all right, but the engine still refused to start. Finally it was decided to put some heavy cylinder oil in the cylinders, and after putting about one quart in each cylinder an attempt was again made to start, and this time with success, proving there was not enough compression.

R. G. Curren, Jr.

Kittanning, Penn.

Piping Troubles

The conditions described here were actually found in practice. At a generating station in a loft building, one engine had a bent crankshaft and a broken bearing. The cause was not hard to find; the engine was over a hundred feet from the boiler and there was no separator in the steam line.

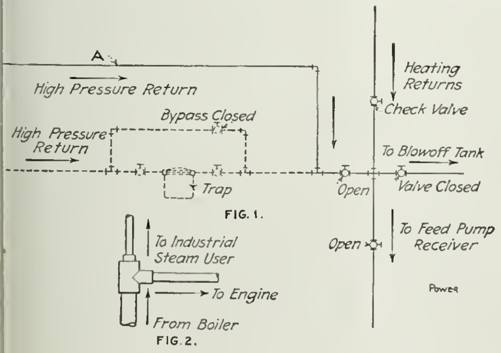


FIG. 1.

FIG. 2.

Faulty Piping

In another plant where high-pressure steam was used throughout the building for industrial purposes, some of the tenants complained about the poor heating service. The piping was followed out and appeared to be correct until the junction of the return pipes, Fig. 1, was reached. Here the high-pressure return pipe line *A* was not trapped, so that high-pressure steam went directly into the pump receiver. This pressure on the discharge side of the check valve prevented the return of the heating condensate and caused the pump to knock. A trap, shown in dotted lines, placed in this line removed the difficulty.

Guests who were unfortunate enough to occupy rooms near the water line in a certain large hotel, never willingly occupied them again. The water was pumped through this line to the roof house tank by a geared triplex pump, and when it was in operation the noise was transmitted along the entire line. This was stopped by cutting about four feet of pipe out of the line near the pump and substituting a strong rubber hose, securely fastened at each end.

Another interesting case, Fig. 2, was found in a plant which carried 95 lb. pressure at the boilers, but could not get more than 90 lb. on its industrial steam system. The pressure was taken from the line which supplied the engine instead of from the boiler direct.

Albert H. Israel.

New York City.

Peculiar Experience with Graphite

On opening a water-tube boiler in which I have been using graphite, I found in the front water leg about 1½ gal. of black balls ranging in size from a small marble to a walnut.

I have been using graphite in the same boilers and feeding it through the heater in the same way for the past year, but this is the first time it has balled up in this fashion. The last shipment, which has been used for about a month, may be of a grade different from that formerly employed. Some engineers think that when a boiler is once coated with scale, graphite will not loosen it up; this is not my experience.

About a year ago, the boilers were coated with $\frac{1}{16}$-in. scale. I used graphite for four months and the scale dissolved and disappeared. On the boiler inspector's last trip he congratulated me on the good condition of the boilers; said they looked like new. I have found no bad effects from the use of graphite.

W. H. Corbin.

Sharples, W. Va.

Babbitting a Crosshead Shoe

It became necessary to babbitt one of the crosshead shoes of a vertical ammonia compressor. Our lathe was not big enough to swing it, we decided to babbitt it in place.

The crosshead was brought up nearly to the top of the guides and carefully centered. The connecting-rod was disconnected and the defective shoe taken out. The old babbitt was chipped out and the shell cleaned with gasoline and put back in place on the crosshead. The adjusting wedge was set so as to bring it as close as possible to the crosshead to allow the maximum amount of metal between it and guide.

The good shoe was then brought tightly against the guide by placing blocks of wood against the piston rod on the opposite side and using wedges to tighten them.

Pieces of one-inch board about three inches wide and a little longer than the shell were placed on each side and wedged in place. A piece was formed to the shape of the guide and blocked in place at the lower end. The openings and joints were filled with fire clay and the metal poured in until it came up even with the top of of the shoe.

When it had cooled the shoe was taken out, scraped and trimmed, and put back in place and adjusted to an easy-running fit. It has been running since then without trouble.

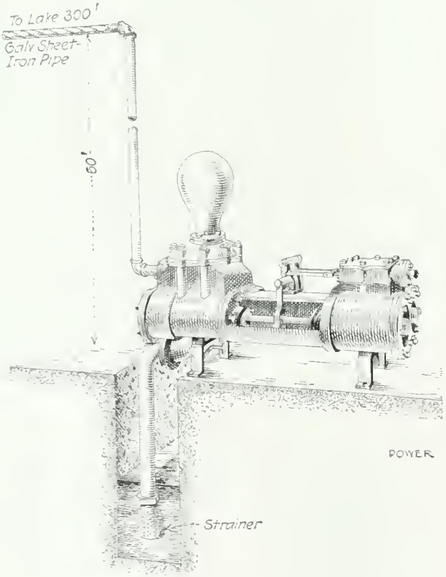
Thomas G. Thurston.

Chicago, Ill.

⁂

Air-Pressure Collapsed Thin Pipe

A curious accident happened to the discharge pipe of a pump located in a large, deep well to remove the surface water while digging. From the pump to the top of the well, standard iron pipe was used, and from the well to a lake, a distance of 300 ft., at a slight elevation, 6-in. galvanized sheet-iron pipe of No. 20 gage was used. All went well for several days until it was necessary to stop the pump on account of trouble in the water end. No provision was made for gradually draining the pipe, so that when the pump head was removed the rush of water down the pipe formed a partial vacuum in the line, which caused about 50 ft. of the sheet-iron pipe to collapse, so that it had the appearance of having been run between a pair of rolls. A wooden trough was substituted and further trouble was obviated.



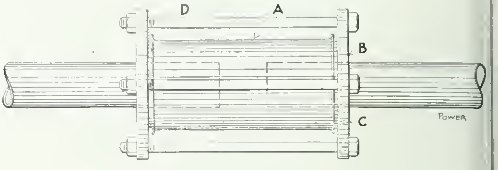
Discharge Pipe Collapsed

John F. Hurst.

Louisville, Ky.

An Emergency Pipe Repair

The discharge pipe leading from a pump, which was used to drain a pit, was accidentally broken at a joint. It was decided that the best way to repair it would be as follows, because the pipe was of odd size and no special fittings could be found.



Repair Job Completed

A piece of pipe *A* of slightly larger diameter than the one to be repaired was cut off and heated so it could be flared out at the ends. Two plates *B* were bored out to fit over the smaller pipe and drilled for the fou bolts *D*. This rig was put on the pipe as shown, packing *C* was inserted and the bolts drawn up snug. Whe the water was turned on, there was no leakage and the jo was satisfactory.

Earl Pagett.

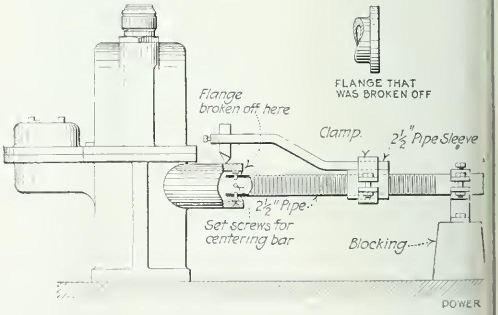
Coffeyville, Kan.

⁂

Repairing a Turbine Steam Connection

The illustration shows the rig we used for threading a turbine inlet and refitting a flange broken off by sever water-hammer in the steam line.

The flange and inlet neck were cast with the lower hal of the turbine. As there was no machine shop availabl with a lathe large enough to swing the base, we decided to do the job as shown, and did not have to dismantle th machine.



Rig for Truing and Threading

A 2½-inch pipe was used for a bar. A toolholder wa attached to an ordinary pipe sleeve that worked on running thread on the pipe. The bar was centered b the setscrews at the end. The tool was ground flat an turned with a wrench on the sleeve, and the neck turne to size ready to thread. Then the tool was ground V shape and a standard pipe thread cut.

The same flange that had been broken off was bored out and threaded to fit the neck. When the job was completed it carried 175 pounds steam pressure and was entirely satisfactory.

FORREST A. JONES.

Minneapolis, Minn.

◆

Sawtoothed Boiler Joints

At a recent meeting of the Engineers' Club of Boston reported in the June 2 issue, page 794, reference was made by a speaker to sawtooth straps for boiler seams. Since such straps are not commonly employed in boiler designs in the United States, an examination of the reasons for their use may be of interest.

Boiler seams must be tight to prevent leakage and strong to resist the tendency for the internal pressure to rupture them. Since the joints are made tight by calking the edge of one sheet against another, the two sheets must be held together rigidly enough to make the calking a success. This necessitates close spacing of the rivets, so that the plates will not spring apart at the calking edge when the calking is done. The calking edge of a seam, where the plates do not fit together properly, is about as in Fig. 1, the metal along the overlapping edge of the plate at *A* being upset until it presses closely enough against the lower plate to make a watertight joint. For a given thickness of plate, the pitch of rivets *B*, Fig. 1, and the distance from the edge of the plate *C* determine whether the seam can be successfully calked.

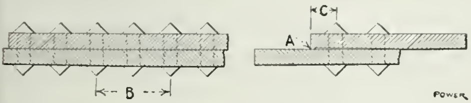


FIG. 1

The size of the rivet heads is also a factor, for they support the plate rigidly up to the edge of the heads. These three factors determine the practical limit for the pitch of rivets for boiler seams: thickness of plate, size of rivets (which determines the size of heads), and the distance the rivets are placed from the calking edge of the plate or strap. The distance of the rivet from the edge of the plate is fixed in the case of longitudinal seams by the necessity for providing sufficient metal in front of the rivets to prevent them from pulling out through the edge of the plate or strap, instead of shearing the rivets or causing the net section to break.

This requirement causes the dimension *C*, Fig. 1, to be made one and one-half rivet diameters. It should be noted that the span *B* between the rivets affects the stiffness of the sheet as well as that of the calking edge, and along this plate, it is just as important in producing a tight joint as is the stiffness of the calking edge. For this reason, double butt-strapped joints can be successfully calked with a longer pitch between rivets, due to the support given the plate by the inner strap of the joint.

Many years ago, when butt-strapped joints were first used for boiler construction, the two straps placed on each side of the shell were made the same width, and as the rivet spacing along the outer edge of the strap had to be close enough to permit tight calking, joints of high efficiency could not be obtained with this design. In the United States, this difficulty was solved by making the inner strap wider than the outer, so that the calking edge would come where the rivets were spaced closely. Fig. 2 shows the double-strapped joint with the two straps the same width; it will be seen that the rivet spacing in the outer row along *A* and *B* will be determined by the thickness of the strap *t* and the distance of the rivets from the edge of the strap *L*. The efficiency of this type of joint exceeds comparatively little that of a double-riveted lap joint, on account of the limitation to the rivet spacing along the calking edge. The modification of this joint used in the United States to overcome the defect of low efficiency is shown in Fig. 3, where the outer strap is narrower than the inner, and the rivet pitch in the outer row has practically nothing to do with the stiffness of the calking edge on the outer strap.

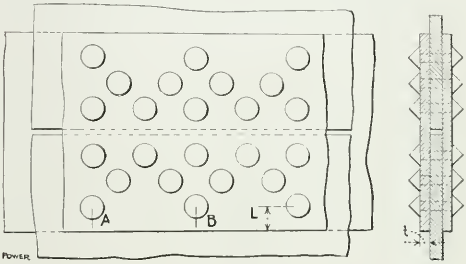


FIG. 2

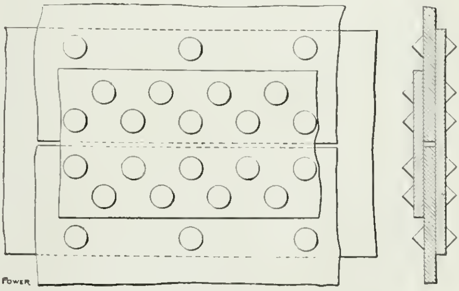


FIG. 3

Foreign boiler manufacturers do not seem to favor this style of joint; they use the kind having the two straps made the same width. The low efficiency has been practically overcome by serrating the edges of the other strap, as in Fig. 4, which illustrates a quadruple joint of this style.

It is difficult to see just what advantage the joint shown in Fig. 4 has over that in Fig. 3. The claim is that the strain due to the circumferential pull is not on one side of the joint, as is stated to be the case with joints like Fig. 3, where one of the straps is wider than its mate. The outer butt-strap in Fig. 4 removed the defect of the long span between rivets on the calking edge which existed in the seams made like Fig. 2 when they were designed for maximum efficiency. The style of joint shown in Fig. 4 requires usually that the outer straps be better fitted to the shell than in either of the other styles shown to produce a tight seam without excessive calking. This can hardly be called an objection if good fitting is demanded rather than excessive calking. It is comparatively easy to fit the outer straps on joints shown in Figs. 2 and 3, so that the calking edges of the straps will be tight against the shell, but since the calking edge of the strap shown in Fig. 4 extends practically half way across its width, the strap and the shell must fit properly across this space unless excessive calking is to be required.

A difficulty occasioned by the use of straps as shown in Fig. 4 is that the calking edge cannot be planed, and since this edge must be machined to make it the proper shape to permit successful calking and to remove the defective material, it is necessary to resort to milling these edges, where the serrated edges have been formed when punching the plate out.

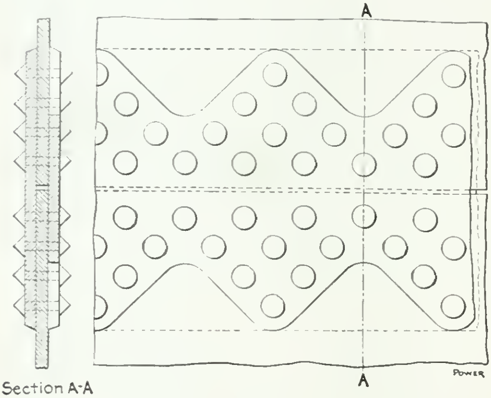


Fig. 4

Since failures have occurred in joints, where the straps were of both equal and unequal width, the American practice, Fig. 3, may be considered the best type of joint for boiler design. The style of joint in Fig. 4 is largely used by German designers and undoubtedly originated in Germany. The one in Fig. 3 was originated by the Hartford Steam Boiler Inspection & Insurance Co.

S. F. Jeter.

Hartford, Conn.

⁂

Saving in Coal Handling

Poor management in handling coal from cars to storage is a frequent cause of loss. I have had occasion to correct some of these losses, and in each case there has been not only a financial gain, but a saving of time and labor in handling a given amount of coal.

In one case, where facilities had originally been provided for using hopper dump cars, the management had permitted the shipping of coal in flat-bottom and side dumping cars to such an extent as to greatly increase the cost of handling. At another plant, where the storage was along the track, wheelbarrows transferred the coal 50 to 75 feet, where it was again shoveled into the small boiler-room car, from which it was fired. By extending this small rai ltrack and installing a switch, the cars were run anywhere in the coal-storage, thus saving the transfer from wheelbarrow to car.

I have found it best for this class of work to employ husky laborers who can use large scoops, and to pay them by the ton for unloading. A good shoveler can make excellent wages at 12 cents per ton when unloading from the ordinary car.

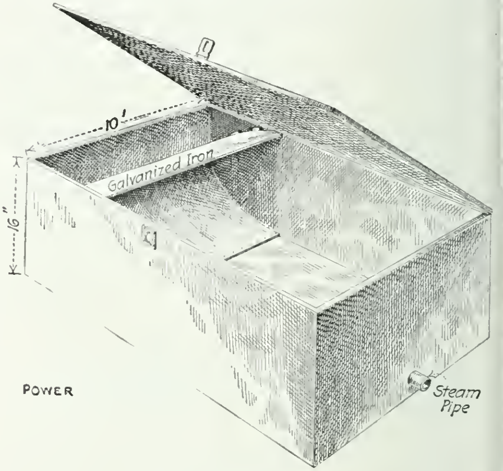
B. W. Dennis.

Columbus, Ohio.

⁂

Steam Washer for the Plant

This washer for oversuits is made out of a store box. I put a sheet of galvanized iron in one end to make a half circle. Then I hinged on a lid and attached a $\frac{3}{4}$-in. pipe to be connected to a steam hose. I put in one garment at a time; then close the lid and turn on the steam for 3 or 4 min. This will turn them over and over and boil all the grease out.



The Washer Complete

Earl W. Cook.

Cherry Tree, Penn.

⁂

Keeper for Valve-Gear Keys

Engines of the Corliss type should have the valve-gear keys held in place by keepers which will prevent the keys from working entirely out while running. The keys giving the most trouble on engines of the older makes (with long dashpot rods) are those on the steam-valve stems, probably due to the vibration of the dashpot.

In refrigerating or central-station plants, where it is inconvenient to shut down to replace a key, this can be done, without shutting down, if the engine is not overloaded, by simply shortening up the dashpot rod until the steam hook ceases to engage the valve arm. With this at rest the key can be replaced and the dashpot rod lengthened again until engagement takes place. This operation will probably be attended by some variation or racing, but this is preferable to a shutdown.

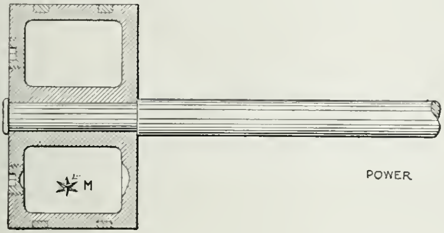
John F. Hurst.

Louisville, Ky.

Core Cleaner Left in Piston

Soon after a new piston was made for a high-speed engine, the latter developed a slight click in the cylinder. The shop man was called in and found that one of the pipe plugs that stopped the core holes was leaking.

A new one was put in, but in a few days trouble again developed. This time the pipe plug, which was of the countersink kind, had a considerable opening in it, so it was taken out. Inside the piston head, there was a chilled cast-iron star which is used by foundrymen for cleaning hollow castings. The constant motion was causing it to cut its way through the piston head, the rear wall being nearly cut through. I have known of several engines being wrecked from such a cause, even when the click was only slight.



Core Cleaner Left in New Piston

C. R. McGahey.

Baltimore, Md.

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Operating Costs of a Small Oil-Engine Plant

The editorial in the June 3 issue regarding the use of oil engines is timely, and the subject is deserving of serious attention. However, it should not be assumed that the oil engine is an untried prime mover, for in the West and Southwest there are innumerable plants, both large and small, depending upon oil engines for power. As for service, these engines are fully as reliable as steam engines and the plant far less complicated.

Following is the monthly record of a small light and water plant in Texas, using a distillate oil engine driving a dynamo and a duplex power pump:

OPERATING COSTS

Engine	50-hp., three-cylinder vertical
Generator	30-kv.a. alternator
Pump	6x10-in. duplex power pump
Total kw.-hr. during month	2920
Total hours in operation	182
Average kilowatts per hour	16.15
Water pumped per month, gallons	1,820,000
Pumping head, feet	140
Electrical horsepower (assuming 90% efficiency of dynamo)	4,350
Water horsepower-hours (assuming 60% efficiency of pump)	1,786
Total brake horsepower	6,136
Distillate oil used, gallons	840
Cost of oil at 4½c	$37.80
Gasoline used (starting engine, etc)	50 gal.
Cost of gasoline at 10c	$5.00
Cost of lubricating oil (20 gal. at 35c.)	7.00
Cost of waste (10 lb. at 15c.)	1.50
Engineer's wages per month	70.00
Total operating cost	121.30
Cost per brake horsepower-hour	0.0198

It will be noted that the engine was but little more than half loaded. Consequently the fuel cost per horsepower-hour is higher than if running on a heavier load. Even under these conditions the fuel cost per horsepower is much lower than in the same size steam plant. As for reliability, after the first week, the engineer, who had never operated an oil engine before, had absolutely no trouble either in starting or operating the engine.

L. H. Morris.

Waco, Texas.

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Parallel Field Connections

The proprietor of a steam laundry, becoming impressed with the economy that would result from generating his own electricity for lighting, purchased a small secondhand shunt-wound generator.

The engineer who was engaged to install the dynamo recommended a larger pulley for the countershaft, from which the dryamo was driven, so that it might run at the required speed. The owner, however, refused to make any further outlay, saying that he would cancel the arrangement unless the machine could be installed without the purchase of a pulley. After a conference with an electrician, the engineer changed the field connections from series to parallel so as to attain the desired voltage at the slower speed. The owner was satisfied, but did not know that the field was taking over twice the former current for excitation and that the electrical energy wasted would soon pay for a pulley.

T. H. Reardon.

Pittsfield, Mass.

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Questions for Discussion

1. I would like the readers to give two sketches of the connections to furnish the following voltages from a bank of single-phase transformers on a 2300-volt, three-phase, three-wire primary. The first sketch should show two single-phase transformers in parallel, furnishing three-phase current at 220 volts, and a three-phase, 110-volt and 220-110 three-wire combination. These transformers must furnish all this at the same time. The second sketch should show the same combination with three single-phase transformers in parallel and in a bank.

C. D.

2. A 50-hp. General Electric, three-phase, alternating-current induction motor is wound for 440 volts; it is desired to change to 220 volts. What changes will be necessary in the windings?

M. F.

3. I intend to test the flue gases of four horizontal, return-tubular boilers burning No. 3 buckwheat coal under forced draft. These boilers are forced to carry the load while two other boilers are being reset. If I find only 5 to 8 per cent. of CO_2 in the gases, this will show excess air. If I then slow down the fans to raise the CO_2, will the boilers steam any better or as good as before? In slowing down the fans to reduce the excess air, could I hold the pressure?

J. M.

4. Believing that Corliss engines should work satisfactorily under a moderate degree of superheat, I should like to hear from readers who have had experience with such cases.

G. U.

Engineers' Study Course

Elementary Mechanics--XIX

LAST LESSON'S ANSWERS

81. The acceleration due to gravity decreases the farther the body is from the center of the earth; that is, the acceleration of a body at the top of a mountain would be less than at the sea level.

82. Since the body is falling with an acceleration of 32.16 ft. per sec. per sec., the velocity at the end of 4 sec. will be

$$4 \times 32.16 = 128.6 \textit{ ft. per sec.}$$

The average velocity during the entire 4 sec. was the sum of the initial and final velocities divided by 2, or

$$\frac{0 + 128.6}{2} = 64.3 \textit{ ft. per sec.}$$

Therefore the body must have fallen

$$4 \times 64.3 = 257.2 \textit{ ft.},$$

which distance equals the height of the stack .

83. The time that will elapse before the velocity of the body becomes zero may be found from equation (44), where $T_1 = \frac{U}{g}$. In this case $U = 84.$ ft. per sec. and $g = 32.16$, hence

$$T_1 = \frac{84}{32.16} = 2.6 \textit{ sec.}$$

84. The vertical distance through which an object falls, due to gravity, is given by equation (42), where $H = \frac{1}{2} gT_1^2$. If the time is 2 sec., the distance H will equal

$$\tfrac{1}{2} \times 32.16 \times 2^2 = 64.32 \textit{ ft.}$$

In problem 82 the height of the stack was found to be 257.2 ft., hence at the end of the second second the object was

$$257.2 - 64.32 = 192.9 \textit{ ft.}$$

from the ground. This shows that the object in the first two seconds (one-half the total time of flight) falls a distance of only ¼ the height of the stack.

85. From equation (43) $V^2 = 2\,gH$. The velocity of the water emerging from the base of the standpipe will then equal the $\sqrt{2\,gH}$, or

$$\sqrt{2 \times 32.16 \times 50} = 56.7 \textit{ ft. per sec.}$$

FALLING BODIES (CONTINUED)

The statement made at the close of the last lesson may be proved by substituting the proper values of a and S in equation (38). If a body is projected vertically upward, and then falls back to its starting point, evidently the net space passed over is zero and hence the value of S in equation (38) becomes zero. Therefore, when $S = 0$ and $a = g$, there results

$$S = UT - \tfrac{1}{2}\,aT^2$$

or

$$0 = UT - \tfrac{1}{2}\,gT^2$$

and

$$UT = \tfrac{1}{2}\,gT^2$$

hence,

$$T = \frac{2U}{g}$$

where T represents the whole time of flight.

In the example just solved, it was shown that the time of fall T_1 was equal to $\frac{U}{g}$. Therefore, the time of rise must equal the whole time of flight T minus the time of fall T_1, or

$$T - T_1 = \left(\frac{2U}{g} - \frac{U}{g}\right) = \frac{U}{g}$$

which is the same as the time of fall. Likewise the velocity at the end of the fall will be given by the equation $U = gT_1$, which is the same as the initial velocity of the body. Hence *a body projected vertically upward will require the same time to fall as it did to rise; and will reach the ground with the same velocity as that with which it was projected upward.*

The equations for falling bodies may then be summarized as follows:

$$V = gT_1 \qquad (41)$$

$$H = \tfrac{1}{2}\,gT_1^2 \qquad (42)$$

$$V^2 = 2\,gH \qquad (43)$$

$$T_1 = \frac{U}{g} \qquad (44)$$

where T_1 is the time of rise or fall in seconds; H is the vertical distance (in feet) the body has fallen; V is the velocity at the end of the fall, expressed in feet per second; and U is the velocity in feet per second with which the body was projected upward.

LAWS OF MOTION

Thus far the motion of a body has been discussed without any reference being made to the forces producing the motion. For a clear understanding of the three laws of motion, as stated by Sir Isaac Newton, it will be necessary to define certain terms which are involved in these laws.

The *mass* of a body is the amount of material in the body. A cubic foot of iron and a cubic foot of wood occupy the same space, but experience teaches that the iron requires more force to put in in motion than does the wood, or if equal forces are applied to the two bodies the iron will move with a less acceleration than the wood.

The property of matter whereby force is required to change the state of rest or uniform motion of a body is called the *inertia* of the body. This property of matter accounts for the fact that it requires much more force to start, or put a body in motion than it does to keep the body moving at a uniform rate. A fireman in the boiler room finds it much harder to start a coal truck in motion than he does to keep it moving across the boiler-room floor.

The *density* of a body is the mass of a unit volume of the body. The British unit of mass is called the Imperial pound, and consists of a lump of platinum deposited in the Exchequer office.

Let

M = The mass of the body;
V = The volume;

and

d = The density;

then,

$$M = V \times d \qquad (45)$$

or the mass of a body is equal to its density times its volume. The density of a body depends upon the relative closeness of the molecules of the body.

Momentum is the amount of motion in a body and is measured by the product of the mass times the velocity of the body. As defined in an earlier lesson, force is that which changes or tends to change the state of rest or motion of a body. Hence the true measure of a force is the amount of motion destroyed or generated by the force in a given unit of time. Let m = the momentum of a body and V its velocity, then by definition,

$$m = M \times V \qquad (46)$$

Law I.—Every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by imposed forces to change that state.

This law is proved by common observation. Thus the piston of an engine would continue in motion if it were not for external forces which are brought to bear upon it. A bullet shot from a gun would move in a straight line with a constant velocity if it were not for gravity exerting a downward pull upon it and the air offering a resistance to the motion of the bullet. This law shows the effect of the inertia of a body, for, to change the motion of a body, its inertia must be overcome and this can be done only by the application of forces external to the body itself.

Law II—Change of motion is proportional to the impressed force and takes place in the line of action of the force.

As previously stated, the momentum is the quantity of motion in a body and therefore any force which produces a change of motion must be proportional to the momentum of the body. If the mass remains constant, the change in momentum will be dependent upon the change in velocity which, by definition, is the acceleration.

Let

F = The effective force producing motion;
M = The mass of the body;

and

a = The acceleration.

Then the effective moving force (F) will equal the product of the mass (M) times the acceleration (a) if the unit of force is taken as that force which will give to a unit mass in one second an acceleration of one foot per second per second. This unit of force is called the *poundal*. Hence,

$$F = M \times a \qquad (47)$$

The poundal is called the absolute unit of force because its value is not dependent upon the force of gravity, which changes with the location of a body relative to the center of the earth.

The *weight* of a mass of one pound is the force with which gravity draws the given mass toward the earth; hence, from equation (47), the weight of one pound is equivalent to 32.16 poundals of force, since gravity produces an acceleration of 32.16 ft. per sec. per sec., or expressed as an equation,

$$W = M \times g \qquad (48)$$

If the unit of force be taken as the weight of one pound, it will equal 32.16 poundals, or the poundal is equal to about $\frac{1}{2}$ oz. avoirdupois. It is well to note that while the mass of a body remains constant, the weight of the body will vary depending upon the location of the body, for it has been shown that the value of g varies. When the weight of one pound is used as the unit of force, it is called the *gravitation unit of force*, since its value depends upon the value of g.

Therefore in equation (47) the forces F may be expressed in pounds instead of poundals, if the value of M as given by equation (48) be substituted, thus,

$$F = \frac{W}{g} a \qquad (49)$$

where

F = The effective moving force in pounds;
W = The whole mass moved in pounds;

and

a = The acceleration in feet per second per second.

Law III—To every action there is an opposite and equal reaction. This law was discussed under Lesson I, to which the student is referred.

Study Questions

86. Due to the force of an explosion, a piece of boiler plate was projected vertically upward with a velocity of 100 ft. per sec. How far was the plate from the ground at the end of the second second?

87. What is the density of water; of coal? Explain the difference between density and specific gravity.

88. What force in poundals will produce an acceleration of 4 ft. per sec. per sec. on a mass of 100 lb. (neglect friction)?

89. An electric crane raises a flywheel weighing 10 tons with an acceleration of $1\frac{1}{4}$ ft. per sec. per sec. What is the tension in the hoisting cable?

90. If the wheel is brought to rest with a retardation of 2 ft. per sec. per sec., find the tension in the cable while the wheel is coming to rest.

Vasil Shaking and Dumping Grate

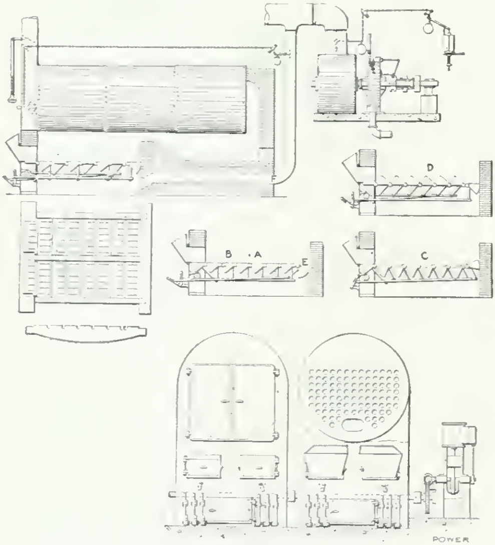
A combination shaking and dumping grate, designed for burning fuel either mechanically fed or hand fired, is illustrated herewith. The grate surface is made up of one, two or more sections reaching across the width of the furnace. Each section is independent of the other, but all work in unison when the stoker is in operation.

The sections are secured to a shaft which oscillates in side-bearing beams; the tops are flat, so that when the grates are as shown at A, the total grate area presents an even surface. The sections are fan-shaped, with the inside end so curved as to bring the end B close to the small end of the next section, no matter what the position of the section except when dumping, as shown at C. At D, the grate is shown with the sections at their extreme forward position.

Movement of this grate, which is made by the Vasil Fuel & Steam System Co., 140 Broadway, New York

City, is obtained from a shaft running across the front end of the furnace under the dead plate: this shaft is fitted with clutch gears made with a blank section. Each gear engages with a short rack, which operates a carrier arm connecting with an arm extending down from each grate section. As the gear revolves in the direction of the bridge-wall, the rack is moved toward the front of the furnace, which rotates the grate to the position shown at *D*, until the blank section comes opposite the rack, when the grates will fall back to a level position *A*. This movement breaks up the fuel and at the same time moves it toward the rear end of the furnace. When desired, the clutch gears can be thrown out of mesh with the rack, and the grates operated by hand to increase the stoking action or to dump the ash and clinkers into the ashpit by manipulating levers on the front of the furnace.

At the rear end of the grates is a dumping plate *E*, which remains stationary while the stoker is in operation; it is operated by a hand lever from the front of the furnace when it is desired to dump the ashes.



Details of Vasil Shaking and Dumping Grate

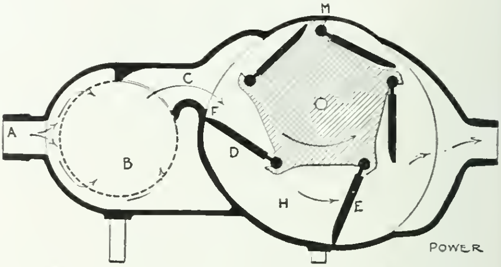
Fuel is deposited in the hopper, which is attached to the furnace door and can be swung out of the way to permit of hand firing if necessary, and for working the fires. Forced draft is supplied by a turbine blower through an air duct *F*, which discharges into the ashpit. The turbine is under the control of a damper regulator; there is also a hand control for the uptake damper.

⁂

Kreutzberg Volumetric Air Meter

This device measures the air used in pneumatic tools. Referring to the illustration, the inlet *A* admits air to the screen chamber *B*. The air then passes into the meter through the passage *C* and, impinging against the vane *D*, causes the drum to revolve. As the vane *D* passes the point of cutoff at *F*, a fixed volume of air is contained between the vanes *D* and *E*. As soon as *E* reaches the outlet the pressure in the pocket *H* is discharged into the pipe line. The meter is sealed at the top by the shoe *M*.

The meter is calibrated to the volumetric displacement, and for noncompressible fluids the readings are taken from the register itself. In gaseous fluids the volume of the atmospheric pressure is directly proportional to the pressure in the atmospheres at which the fluid is measured.



Section through Volumetric Air Meter

The energy required to operate the meter, which is manufactured by the Kreutzberg Meter Co., 1112 City Hall Building, Chicago, Ill., is a fraction of an ounce, and the pressure on both sides of the vanes differ only by the amount of pressure required to operate the meter.

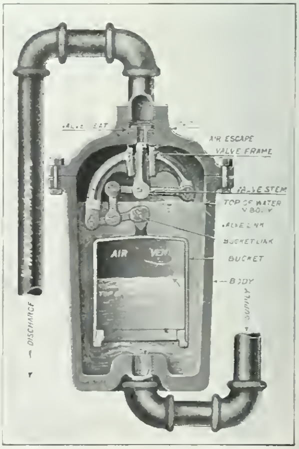
As the meter is made of bronze, corrosion is eliminated. It is adapted to measure steam and gas as well as air.

⁂

Armstrong Steam Trap

A departure from the usual designs of steam trap is the inverted submerged-bucket type made by the Armstrong Machine Works, Three Rivers, Mich.

As shown in the sectional view, the inlet is at the center of the bottom, immediately underneath an inverted bucket. Normally, the weight of the bucket causes it to rest on the bottom of the trap, holding the valve wide open. Small feet on the bucket raise it so that condensation can flow underneath into the trap body. The water fills the body and the bucket, the air in the latter escaping through a small vent into the top of the trap body and out through the outlet provided. The trap is therefore filled with water, and as long as it continues to enter, the bucket will remain on the bottom and hold the discharge valve open.



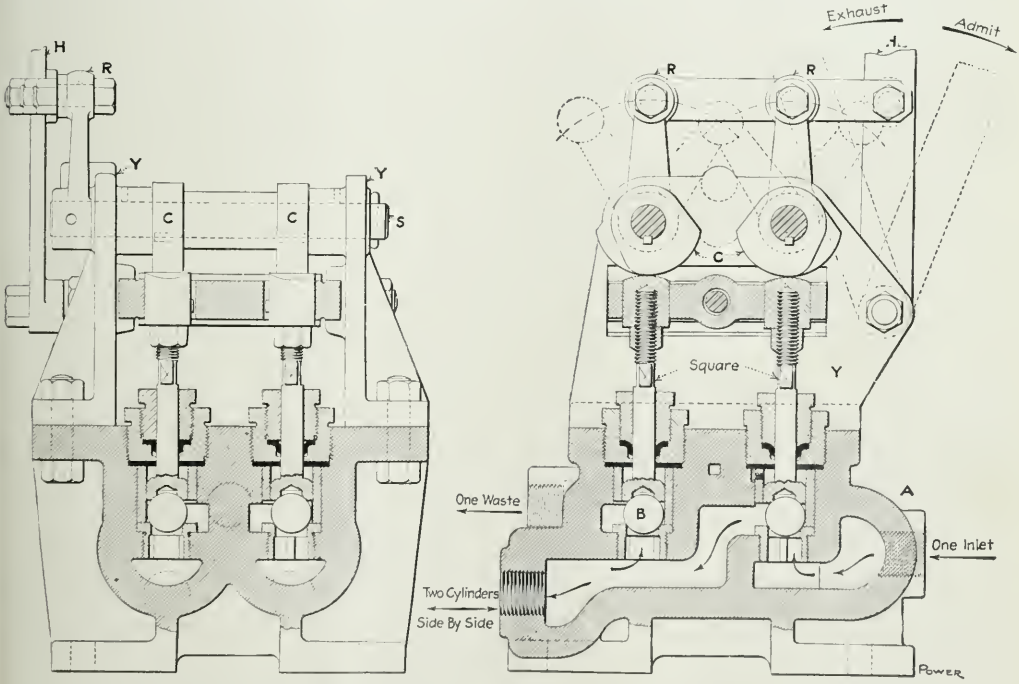
Sectional View of Steam Trap

When steam enters the trap, it rises to the top of the bucket, displacing the water and increasing the buoyancy until the bucket rises and, through the system of levers shown, closes the valve. A little steam will naturally pass through the air vent, but as the pressure forcing it through is only 1 to 3 oz. per sq.in., the quantity will be so small that it will be readily condensed and there will be no accumulation in the top of the trap. The full travel of the bucket is about 1 in. Due to the powerful system of levers, the outlet valve can be large and the capacity of the trap great for its size.

One of the strong points claimed for it is that air binding cannot occur. The valve diameter is varied from 1/8 to 5/16 in., with capacities ranging from 230 lb. per hr. for the smallest size and 1 lb. pressure to 15,600 lb. for the largest valve and 200 lb. pressure.

Schnicke Operating Four-Way Valve

For operating hydraulic machinery in steel mills and manufacturing plants there has been placed on the market the Schnicke hydraulic operating valve. It has a horizontal valve chamber *A*, which is provided with pressure and waste ports, stuffing-boxes, bushing and seat rings. A yoke *Y* is bolted to the top of the valve chamber and forms the bearings for the end of the camshafts *S*. The cams *C* and rocker-arms *R* are keyed to the shafts, which are rotated by connecting the upper ends of the rocker-arms to the hand lever *H*.



Section through Operating Four-Way Valve

As shown in the illustration of a four-way valve, seat rings are screwed into the pressure and waste ports of the valve chamber. Between the seat and the stem a hard bronze ball *B* is employed, which changes its position at each operation of the cam. The upper end of the stem is threaded into a bearing, which travels through a web in the yoke castings; the lower part of the stem is held in position by the stuffing-box, gland and bushing. The cams are oppositely mounted on the shafts and are so arranged that when moving the hand lever in one direction the pressure port is closed before the waste port opens, and *vice versa*.

By applying power to the hand lever, the upper ends of the rocker-arms are forced in one direction or the other, thereby rotating the shafts on which the cams are mounted. When the lever is thrown in the direction to allow the pressure valve to open, the fluid pressure raises the ball from its seat and passes to the machine. While the pressure port is open, the waste port remains closed until the pressure on the machine is to be released. By moving the lever in the opposite direction, the pressure port is closed and the waste port allowed to open, thereby releasing the pressure on the machine. As each stem has a square and threaded end, the operator can adjust either valve from the outside without shutting off the line pressure or the connecting valve.

The outside adjustment feature enables the operator, from time to time, to take up the wear on the seats, thereby preventing leakage and maintaining the pressure in the line.

This valve is manufactured by the Schutte & Koerting Co., Twelfth and Thompson Sts., Philadelphia, which is also putting out a three-way valve of similar design.

A Glossary of Public-Utility Terms Compiled from Various Sources

By L. R. W. Allison

With the increasing growth of public-utility enterprises and the jurisdiction exercised over various classes of such properties by state and city commissions, there have come into everyday engineering practice words and terms that have an important bearing in the engineer's work. A correct knowledge of the meaning of such recognized terms is a fundamental feature of engineering education, whether one is connected with a central station or an isolated plant.

These terms are a part of engineering literature, and passing them by is neglecting an opportunity for that broader knowledge which leads to advancement. The progressive engineer should and must know their meaning and significance; he must know how and when to apply them in his daily contact and dealings, and when called upon to express opinions at board meetings and the like, he must know the correct way to employ them.

Public-utility terms, in the broader sense, deal not only with operation but with construction, financial, accounting and cost factors, all of which interlock as a part of the engineer's province. The accompanying glossary summarizes such terms in current use, and is a concise reference work.

ACCESSORY ELECTRIC EQUIPMENT: Busbars, station cables, regulators, station switchboards and such apparatus as ammeters, voltmeters, wattmeters, switches, circuit breakers, with foundations and settings, and station terminal board, special high-tension transmission equipment; pump and air-compressor motors, and headgate motors.

ACCESSORY GAS WORKS EQUIPMENT: Exhausters, station meters, governors; retort charging apparatus; tar and ammonia apparatus, pumps, pipes, tanks and conveying equipment for the disposal of coke and other products.

ACCRUED AMORTIZATION OF CAPITAL: Depreciation of value of plant and equipment; any other amortization of fixed capital.

AMORTIZATION: Gradual extinction of a charge or charges; clearing off expiring value. Applied to both tangible and intangible property in a comprehensive sense of depreciation in value.

APPROPRIATION ACCOUNTS: A group of accounts which show for any fiscal period the changes in the corporate surplus of a company. Such accounts are usually closed into a general corporate surplus or deficit account at the close of a respective period.

CAPITAL: All property devoted to the production of a company's commodities, and the rendering of service in connection therewith.

CAPITAL, DEPARTMENTAL: A division of fixed capital, being all capital given over solely or primarily to a single and particular class of operations.

CAPITAL, FIXED: Such capital as has a life or expectation of life in service of periods of more than one year.

CAPITAL, FLOATING: A term given to all capital other than fixed capital.

CAPITAL, GENERAL: A division of fixed capital, being such capital as is available for the uses of any two or more classes of operations.

CAPITAL, INTANGIBLE: A division of non-landed capital, being that capital which comprises organization, patent-rights, franchises, etc.

CAPITAL, LANDED: A division of fixed capital, being that which comprises all interests in land for terms of more than one year. Any improvements to the land are usually excluded.

CAPITAL, NONLANDED: A term given to all fixed capital other than landed.

CAPITAL, TANGIBLE: A division of nonlanded capital, being that which comprises structures and equipment having a life or expectation of life in service of periods of more than one year.

CONSUMER DEPOSITS: All cash deposited with a company by consumers as security for the payment of electric, gas or water bills.

CONTROLLED CORPORATIONS: Public utility companies which are controlled through financial interest by another public utility or holding company.

COÖRDINATE DEPARTMENTS: Allied interests of a company which are devoted to subsidiary operations from its main source of revenue. Such as an electric railway company which engages in rendering service in electric light, power, gas, etc.

COST: When used in connection with operating expenses, being the cash or money cost, and distinct from prices based on a term of credit.

DEBENTURE: Any portion of funded debt which is supported only on the general credit of a company, and is not secured by lien, mortgage or otherwise; such as an unsecured promissory note, etc.

DEBT: Absolute obligations to pay money at a specific time or times, or at periods subject to definite demand of a creditor. Contingent obligations, as rent, etc., are usually excluded.

DEBT, FUNDED: All debt of a nature which does not mature until more than one year from the time of its inception.

DEBT, UNFUNDED: All debt of a nature which matures within one year or less from the time of its inception.

DEPOSITS, SPECIAL: Money and bank credits in the hands of agents or other representatives of a company to defray payments of coupons, dividends, or other special purposes. Funds available for general purposes, such as credits at banks subject to check, etc., are excluded.

DISTRIBUTION SYSTEM (ELECTRIC): Overhead or underground distribution system, or both, including distribution main conductors and feeders; all wires, cables, insulators and insulating material and apparatus.

DISTRIBUTION MAINS AND ACCESSORIES (WATER): All land and right-of-way of pipe lines for distribution of water to customers; special castings, gate valves and boxes, regulating valves, air chambers, blow-off cocks, flush plugs and other special equipment.

ELECTRIC OPERATIONS: Operation of a plant for the production of electric energy, transmission of such, and the distribution to consumers for light, heat or power service, and all incidental operations thereto.

GAS OPERATIONS: Operation of a plant for the production of gas, natural or manufactured, transmission of such, and the distribution to consumers for light, heat or power service, and all incidental operations thereto.

GENERAL AMORTIZATION: Accrued obsolescence, wear, tear and depreciation in the respective period in the tangible capital of a company; such portion of the life of the intangible fixed capital as has been consumed or may have expired in the respective period; and any loss of property through extraordinary casualties in the computed period.

GENERAL EQUIPMENT: When used in distinction from general utility operations, infers general shop equipment, general store equipment, general office equipment, and general stable equipment.

GENERAL STRUCTURES: When used in distinction from general utility operations, infers all buildings and other structures of a permanent character used for general purposes, such as office buildings, shops, storehouses, etc., and all fixtures permanently installed.

GOING CONCERN: A term applied to a company when it becomes actively engaged in its particular utility operations, following its preliminary work incidental to such operations.

GOING-CONCERN VALUE: The value which a property possesses, inclusive of its business organization, management and profitable operation, such value being above its physical and other intangible values.

INCOME DEDUCTIONS: Deductions to which a company's gross income is usually subject; these are usually compulsory and for the most part contractural, such as interest accrued on funded debt, sinking fund accruals, rent deductions, etc.

INDICANT ACCOUNTS: A group of accounts comprising asset, liability and fixed capital accounts; also known as the "Balance Sheet."

INVESTMENTS, BOUND: Investments which are subject to a lien or claim of some character.

INVESTMENTS, FREE: Investments which are free of all liens or claims.

JOINT ELECTRIC RENT REVENUE: The profit derived by a company, over and above any allowance for wear, tear and depreciation, in operating a plant for the production of power for the benefit of another company or companies, under an arragement for the division of expenses.

JOINT FACILITY RENTS: The operation of a plant, or any equipment, for the benefit of two or more companies under a joint arrangement for the apportionment of expenses on a basis of the relative amount of respective benefit.

LABOR: When used in connection with operating expenses, being distinctly human services of whatever character.

MESNE ASSIGNMENT: The assigning of property, particularly of the nature of a franchise, by a company to others during the life of the period for which such privilege has been granted.

MISCELLANEOUS POWER PLANT EQUIPMENT: Apparatus intermediary between prime movers and electric generators; mechanical equipment such as pulleys, belts, hangers, countershafts; machine tools, hoists, cranes, etc.

NONOPERATING REVENUES: Revenues derived from property or interests in property by a company when such property is not used directly for operations, but is in the hands of others, such as rents, leaseholds, etc.

OBSOLESCENCE: Equipment and apparatus becoming obsolete and falling into disuse.

OPERATING EXPENSES: Expenses necessary to the maintenance of a company, the production and distribution of its commodities, the rendering of proper service in connection therewith, and the collection of revenues derived from such service.

OPERATING REVENUES: All amounts of money which the company receives or is lawfully entitled to for the distribution of its commodity and services rendered in connection to its consumers; and all returns upon property used by the company in its own operations.

PERIODIC PAYMENTS: Payments guaranteed by a company at a specific time or times to defray an obligation.

PREMIUM REALIZED: The excess of actual money value realized upon any particular stock at the time of issue over the par value of the stock.

PREPAYMENTS: Payments for such items as taxes, rents, insurance, etc., made in advance of the specific period to which they pertain.

PRODUCTION EXPENSES (ELECTRIC): Station wages, fuel, supplies, and repairs to station buildings, steam, electric and hydraulic equipment.

PUBLIC UTILITY: Every individual, association, copartnership, corporation or joint stock company that owns, operates, manages or controls any electric light, heat, power, water, gas, oil, sewer, telephone or telegraph, plant or equipment for rendering public service; also any steam railroad, street railway, traction railway, canal, express, subway or pipe line.

PURIFICATION SYSTEM (WATER WORKS): All land, structures and equipment employed in connection with the purification of water, and in conveying water from one part of the purification system to another; and power plant and pumping equipment used for the delivery of wash water for filter or sand washing.

REACQUIRED SECURITIES: Securities that have been issued to bona fide holders for value, and later reacquired by a company; such securities are usually either stocks or funded debt.

RESERVES, CONTRACTUAL: Such reserves as are necessitated by contracts of a company, such as reserves to cover sinking funds as stipulated in mortgages, etc.

RESERVES, NONCONTRACTUAL: Temporary reserves as are raised without being required by any contract or agreement.

RESERVES, OPTIONAL: A division of noncontractual reserves, being those created solely at the discretion of a company.

RESERVES, PERMANENT: Reserves that must be maintained intact during the life of a company, such as premiums on stocks, etc.

RESERVES, TEMPORARY: Reserves not intended to be held intact during the life of a company.

SINKING FUNDS: Funds maintained for the purpose of redeeming outstanding obligations.

STOCKS: Securities which represent permanent interests in the company, such interests which, if terminable, are only so at the option of such company.

STOCKS, DEBENTURE: Stocks issued under a contract guaranteeing payment thereon of a specified return at specific periods.

STOCKS, COMMON: Stocks whose claims in the distribution of dividends are subordinate to those of all other stocks.

STOCKS, FIRST PREFERRED: Stocks whose claims in the distribution of dividends are foremost above those of all other stocks.

STOCKS, SECOND PREFERRED: Stocks whose claim in the distribution of dividends are next after those of first preferred stocks.

SUSPENSE: Used in connection with a system of accounts, being any expenditure made in which the exact disposition is not immediately determinable; the occurrence of any loss spread over a period of time; and when any debit is amortized through charges made to expense or other income accounts over a period of time.

TRANSMISSION SYSTEM (ELECTRIC): Under usual conditions, the outside lines and conductor system to the point of step-down transformers or motor-generator sets, etc., including wires, cables, insulators and insulating materials and apparatus.

TRANSMISSION MAINS AND ACCESSORIES (WATER): Used only in connection with water works operating pumping stations, being all land and right-of-way of main pipe lines which convey water for long distances without any connections for service, from the pumping station to the distributing storage reservoir or distributing system mains; with special castings, valves, valve vaults, boxes, etc.

UNAMORTIZED DEBT DISCOUNT AND EXPENSE: The excess of the sum of the par value and accrued interest over the cash value of the consideration received from the sale of funded debt securities and other evidences of indebtedness, when such are disposed of for a sum less than the par value.

UNAMORTIZED PREMIUM ON DEBT: The excess of the sum of the cash value received over the par value and accrued interest from the sale of funded debt securities and other evidences of indebtedness, when such are disposed of for a sum greater than the par value.

WATER COLLECTING SYSTEM: Structures and equipment used in the collection of water, and its conveyance from the point of collection to the purification or pumping plant. Or in the case of a gravity system, to a point from which it is distributed to consumers.

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Industrial Education and the Engineer

By E. H. FISH

Massachusetts has now some nine schools for the industrial education of boys, in three or four of which experiments are being tried in training engineers. The state law contemplates the admission of pupils at any time after they are 14 years old. The average age at admission, however, is at least 15, but even then a two-year course, as given at some schools, would make the graduates only 17 and the four-year courses in other schools, 19 years old, both considerably below the age of sufficient maturity for responsible work around engines and boilers. This is not altogether a misfortune, for the intervening years may be profitably spent in subordinate positions where, even if the pay is small, the experience is good.

These schools do the best they can in giving the pupils a taste of the real life of a fireman and engineer, but of necessity their service plants are small and their experimental plants are smaller. In Worcester there are two vertical firetube boilers each of 100 hp. The service engine is a Westinghouse compound of 75 hp. There is a spare engine used for service during the lighting season and for experiment the rest of the year. This is a high-speed, inertia governor engine of 90 hp. These two machines are connected to 55-kw. generators, one of them a three-phase 220-volt machine, the other a direct-current generator of the same voltage which is used to supply light when the first generator is overloaded. There are four other smaller slide-valve engines, one with a riding cut-off and centrifugal flywheel governor, the others with throttling governors. There is also nearly complete a small Corliss engine on which the pupils in the machine shop have been working as opportunity offered for the past year and a half. This is as comprehensive an equipment as such a school can reasonably be expected to furnish unless a much greater demand for such training should come than has at present appeared. The New Bedford school has a 50-hp. producer-gas plant and engine which it uses for a service plant, but the others for the most part have even more meager equipment. Smaller apparatus, pumps, injectors, valves, gages, etc., are easily obtainable from the makers so that there is no difficulty about adequately presenting that subject.

All of the schools have good opportunities for steamfitting work in connection with their own plants. The same is true of electric wiring. In Worcester, the pupils have done all the steamfitting, not merely for the experimental engines, but for the heating, by vacuum system, of the recent addition of nearly an acre of floor space. They have also put in the lighting system, including the switchboards, which they have built, and the installation of half a dozen motors. In fact, these are the easiest things to handle in connection with such a course; the most difficult is that connected with what may be called purely service work. Only two boys can be kept busy at once in the service plant actually firing and looking after the engine—more would be in each other's way. Furthermore, they would have a tendency to fool that would be bad for them and for the school, for if there is any place where strict attention to business is essential it is in the engine room. Three or four boys can be kept busy around each engine to advantage so long as it is used for experiment. They can learn to set valves, to adjust and scrape bearings, to locate knocks, take indicator diagrams, etc., but they get but little idea of looking far enough ahead to keep the engine running under all conditions; these they must get in the service plant of the school, or else in some plant outside.

The electrical work, however, is the thing that draws the largest number of boys. They often come with the idea that that is all there is to an engineer's duties that makes them worth doing. Except for the fact that it is impossible to give them experience with really heavy generators and high voltages, this is the easiest thing to handle of all. Wire can be used over and over again, lights and motors can be installed for the use of other departments, and if that work should run low there is plenty of chance to relocate both motors and lights.

After all, the greatest opportunity for the pupils, considered in the light of the usual lack of opportunity, is in the class-room work of a technical nature. The work of an engineer involves considerable technical work, which is not given in its practical aspect in engineering schools. Work of this nature must be given from a simple and practical viewpoint in a trade school or the pupils will not grasp it at all, in which case they will not stay at school. In this work the assistance of textbooks is almost worthless. It must be taught from handbooks, trade catalogs and technical papers. Textbooks attack all these subjects in ways which involve mathematics much beyond the capacity of the pupils of trade schools, and they approach their subjects in the exactly opposite way from that in which the various laws of nature were discovered. That is, they assume that the laws have been correctly interpreted, and then from these laws they proceed to deduce facts which agree fairly well with what is found in practice, instead of beginning with what is found in practice to be true and then from that showing how these laws may be interpreted. It is unfortunate that textbooks which handle things in this latter way are not available, but, on the other hand, it is fortunate that the present condition does not make it possible for men to "fake" teaching, as is possible in colleges.

New England States Convention

The New England States Association of the National Association of Stationary Engineers held its annual convention at Providence, R. I., July 8, 9, 10 and 11, with headquarters at the Crown Hotel.

The meetings of the delegates were held in the assembly rooms of Infantry Hall, and in the large drill room across the hall was the exhibition of power-plant machinery, accessories and supplies, under the auspices of the New England Association of Commercial Engineers. The display on this occasion was the largest yet held and was well attended.

In the exhibition hall at eleven o'clock on Wednesday morning, Major James W. H. Myrick called the assembly to order and introduced Mayor Joseph H. Gainer, who spoke briefly and interestingly of Providence, and welcomed the convention to it.

He was fittingly responded to by Bradford L. Ames, president of the New England Association of Commercial Engineers.

John P. Farnsworth, president of the Chamber of Commerce, was then introduced and talked pleasingly of the early days of engineering and told of the wonderful advancement and of the high standard that was required of the operating engineer of the present day.

W. C. Barnes, vice-president of the association, then addressed the meeting, after which the exhibition was formally opened by Major Myrick.

Delegates and Guests at the New England State

On Friday morning at eleven o'clock the delegates and guests assembled in Infantry Hall for the preliminary exercises of the convention. Riley Daniels, the presiding officer, introduced Aram J. Pothier, governor of Rhode Island, who said how pleased he was to have the convention come to his state, and hoped that the stay in Providence would be both profitable and enjoyable. Asa M. Day, Mayor Gainer, Thomas A. Ray, National President James R. Coe, Mayor G. W. Easterbrooks, of Pawtucket; Mayor Walter F. Snow, of Central Falls; Mayor John W. Horton, of Cranston, and J. T. Maloney, past-president of the Commercial Engineers, also made addresses. The meeting then went into executive session and President Asa M. Day appointed the several committees, after which the meeting adjourned until the afternoon session.

A smoker was held on Friday evening in the banquet hall of the exhibition building under the auspices of the Commercial Engineers. Good things to smoke were distributed, and an enjoyable entertainment was given by Bert Self, Peerless Rubber Manufacturing Co.; Billy Murray and Joe McKenna, Jenkins Bros.; Michael O'Connell, New Jersey Mechanical Rubber Co.; Jack Armour, "Power"; Michael Foran, Bob Jones, Monroe Silver, and Jim Devins. The big number of the night occurred when Master of Ceremonies Frank Martin called F. R. Low and Bradford L. Ames to the stage. Mr. Low, in a few well chosen words, presented a solitaire diamond scarf pin to the past-president of the Commercial Engineers, the gift of his friends among the supplymen.

On Saturday morning at 8 o'clock there was an automobile ride for the delegates through the park system of Providence.

At ten o'clock on Saturday morning the convention enjoyed a steamboat trip to Potter's Cove Club, where a genuine

Rhode Island clambake was served. Before the bake there was a baseball match between the Engineers and the New York "Bunch," which resulted in a victory for the Engineers by the score of 7 to 2.

At the meeting of the delegates on Friday the officers for the ensuing year were elected as follows: Asa M. Day, past-president, New Haven, Conn.; Thomas A. Ray, president, Cambridge, Mass.; Riley Daniels, vice-president, Pawtucket, R. I.; John F. Quinn, secretary, Holyoke, Mass.; Walter Damon, treasurer, Springfield, Mass.; M. M. Childs, conductor, Providence, R. I.; Timothy Horan, doorkeeper, Ludlow, Vt. National President James R. Coe installed the officers and pinned a past-president's jewel on Asa M. Day.

At the meeting of the Commercial Engineers on Friday afternoon, Herbert E. Stone, treasurer, was presented a handsome combination silver cake dish and cut-glass bouquet holder, William K. Campbell making the presentation speech. The election of officers resulted as follows: William K. Campbell, president; James W. H. Myrick, vice-president; Herbert E. Stone, treasurer. Bradford L. Ames, W. Carleton Barnes and Fremont Eggleston, Jr., were chosen for directors for three years, and Brooks Faxon for one year.

Holyoke, Mass., was selected as the convention city for 1915.

EXHIBITORS

Acme Electric Co.
Albany Lubricating Co.
Allen Manufacturing Co., Inc.
American Graphite Feeding Device Co.
American Oil Co.
American Steam Gauge & Valve Manufacturing Co.

Jenkins Bros.
Jefferson Union Co.
Keystone Lubricating Co.
H. W. Johns-Manville Co.
Lunkenheimer Co.
Manning, Maxwell & Moore
Mason Regulator Co.
Massachusetts Fan Co.

Convention, Providence, R. I., July 8-11, 1914

V. D. Anderson Co.
Ashton Valve Co.
Atwood & Morrill
Autoforce Ventilating System
J. Henry Blanchard
Bowers Rubber Works
Brown Bros. Co.
Bryan-Marsh Division National Lamp Works of General Electric Co.
Buhne Metal Packing Co.
Burke Engineering Co.
Builders Iron Foundry
Chapman Valve Manufacturing Co.
A. W. Chesterton Co.
C. A. Claflin Co.
Clement Restein Co.
Climax Smoke Preventer Co.
Crandall Packing Co.
E. M. Dart Manufacturing Co.
M. T. Davidson Co.
Dearborn Chemical Co.
Diamond Power Specialty Co.
Durabla Manufacturing Co.
Eagle Oil & Supply Co.
Gardner Grate Co.
Garlock Packing Co.
General Fire Extinguisher Co.
Greene, Tweed & Co.
A. W. Harris Oil Co.
Wm. A. Harris Steam Engine Co.
Hart-Edison Packing Co.
Hart Packing Co.
Hills-McCanna Co.
Home Rubber Co.
Chas. J. Jagar Co.
Geo. P. Dixon Co.
Griscom-Russell Co.

McLeod & Henry Co.
Narragansett Electric Lighting Co.
"National Engineer"
New York Revolving Portable Elevator Co.
Open Coil Heater & Purifier Co.
Patterson Lubricating Co.
Pennsylvania Flexible Metallic Tubing Co.
Perino Chemical Works
Perolin Co. of America
Peerless Rubber Manufacturing Co.
Philadelphia Grease Manufacturing Co.
"Power"
Providence Engineering Works
Publicity Committee, R. I., N. A. S. E.
Quaker City Rubber Co.
Revere Rubber Co.
Rhode Island Covering Co.
Rhode Island Welding & Sherardizing Co.
Rhode Island Supply & Engineering Co.
Walter G. Ruggles Co.
Spencer Turbine Cleaner Co.
Syracuse Faucet & Valve Co.
Tillotson Humidifier Co.
Thomas Evans
Vanda Co.
Vasil Fuel & Steam Systems Co.
Wholey Boiler Works
Wiener Machinery Co.
E. De F. Wilkinson Co.
Wm. R. Winn

Court Overrules Public-Service Commission

A most important decision has been rendered by the Appellate Division of the Supreme Court of New York in the case of C. Perceval vs. the New York Edison Co.

The case dates back just about a year at which time the complainant, C. Perceval, had in course of construction at Nos. 2-6 Ninth Ave. a building on leased ground and made application to the New York Edison Co. for service connection, refusing, however, to subscribe to the clause in the contract that no other electric service should be used or introduced in connection with the equipment supplied without the written consent of the Edison Co.

In the adjoining building occupied by Frank I. Wing, there was a private plant, which it was arranged should supply the new building from 7 a.m. to 5:30 p.m., the street service to be used only during the night.

The New York Edison Co. refused to sell electricity under these conditions and Mr. Perceval appealed to the Public Service Commission to compel the company to do so.

After a number of hearings the commission reached the decision on Mar. 3, 1914, sustaining the New York Edison Co., holding that a public service corporation may not reasonably be required to furnish breakdown service for a competitor furnishing the same kind of service in the same area.

The case was then taken to the courts and the decision, which reverses that of the Public Service Commission, holds that in consideration of the privileged position of the company, especially in its use of the streets, it must serve impartially every member of the community who demands service. It may establish reasonable regulations, but the requirement that a consumer must take all his energy from one company or receive none is declared an arbitrary attempt on the part of the company to insure to itself a monopoly of furnishing energy.

BOOKS RECEIVED

MATHEMATICS FOR THE PRACTICAL ENGINEER. By Charles H. Bromley and Henry R. Cobleigh. McGraw-Hill Book Co., New York. Cloth; 220 pages, 5¼x8¼ in.; 75 illustrations; tables. Price, $2.

FUEL ECONOMY AND CO_2 RECORDERS. By A. R. Maujer and C. H. Bromley. McGraw-Hill Book Co., New York. Cloth; 189 pages 5¼x8¼ in.; 28 illustrations. Price, $1.50.

METHODS OF MACHINE-SHOP WORK. By F. A. Halsey. McGraw-Hill Book Co., New York. Cloth; 286 pages, 5¾x9¼ in.; 285 illustrations. Price, $2.50.

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Effect of Soot on Vegetation—This is the subject dealt with in Bulletin 7, the latest put out by the Mellon Institute of Industrial Research. The bulletin was written by J. F. Clevenger, botanist for the smoke investigation committee, and the investigation was undertaken by the botanical department of the Pennsylvania State College coöperating with the Mellon Institute. Observations have been made in public parks in Pittsburgh, Chicago and the vicinity, and along railroad lines and in mill districts. The conclusions of other investigators here and abroad are given.

American Boiler Manufacturers' Coming Convention

The American Boiler Manufacturers' Association will hold its 26th annual convention in New York City, Sept. 1 to 4, with headquarters at the Waldorf-Astoria Hotel. All boiler, tank and stack manufacturers, and fabricators of steel plate, also manufacturers and representatives of materials and supplies used by boiler manufacturers, are invited to attend.

A number of interesting papers on subjects of importance to boiler and plate manufacturers will be read. Uniform boiler specifications will be thoroughly discussed, and it is hoped that some action on this subject will be taken at this convention.

If those anticipating attending will send their names to F. B. Slocum, secretary, West and Calyer Sts., Brooklyn, N. Y., or to any of the following members of the publicity committee, arrangements for locating them during the convention will be made:

Publicity committee—H. R. Cobleigh, chairman (managing editor "Power"), Tenth Ave. and 36th St.; George H. Partridge, Sweet's Catalogue Service, Inc., 119 West 40th St.; J. M. Lloyd, "The Iron Age," 239 West 39th St.; Watson S. Anthony, manager, "Industrial Engineering," 120 West 32d St., and George Slate, "The Boilermaker," 17 Battery Place, all of New York City.

* * *

Licensing of Stationary Engineers—An ordinance such as was adopted in Buffalo, prohibiting the granting of a license to a stationary engineer, unless he has been a resident of the city for three years, is unconstitutional as an unreasonable interference with the right to engage in a lawful business, guaranteed by the United States Constitution, according to the decision of the United States District Court for the Western District of New York in the case of Williams vs. McCartan, 212 "Federal Reporter," 345. The court said in this case:

> The state legislature no doubt had the power to authorize the municipality to enact an ordinance requiring applicants for licenses to run stationary engines within the city of Buffalo to submit to an examination as to their qualifications, and to give them, if qualified, a stationary engineer's license of the same relative grade as the United States license held by them, as specified in the charter; but the legislature cannot restrict the issuance of such licenses, without grade classification, to engineers living in the city of Buffalo to the exclusion of nonresidents. . . . The complainant, it is true, had no positive right to a license to run a stationary engine, but he had a right, without respect to residence, to an examination as to his qualifications.

Uniform Boiler Laws for Canada—As a result of a conference held at the Parliament Buildings of the chief boiler inspectors of the different provinces, a uniform set of regulations is to be adopted for the entire Dominion to enable inspection in one province to be accepted in any other. At present Nova Scotia, New Brunswick and Manitoba have no regulations, although the necessary legislation has been passed.

D. M. Metcalfe, chief boiler inspector for Ontario, is chairman of the conference, and associated with him are: W. G. Mathieson, Nova Scotia; John Peck, British Columbia; R. M. Blackburn, Saskatchewan, and P. J. Jobin, Quebec. These men have been engaged revising the regulations and making such amendments as are necessary to bring those of the different provinces into uniformity, and Alberta, New Brunswick and Manitoba will adopt their recommendations when the work is completed.

Projected Canadian Power Plant—Announcement is made at Winnipeg that E. W. Backus, Minneapolis, Minn., has been granted water rights by the Ontario government on an understanding that he will develop 30,000 hp. on the Winnipeg River and erect a pulp mill at Kenora, Ont. It is contemplated that one-half of the power developed will be utilized by the mill.

Extend Service of Municipal Plant—Pasadena, Calif., has been given formal permission by the South Pasadena board of trustees to place conduits and pole lines in that city for the purpose of furnishing energy from the Pasadena municipal electric plant to the citizens of South Pasadena. Principally, the desire of General Manager Koliner is to furnish service to residents on the borderland between the two cities, but as time advances the demand may necessitate the extension of the service further into South Pasadena.

A Prize Competition has been opened to the employees of members of the Society for Electrical Development, Inc. The society offers eight prizes, $250, $150, $50 and five of $10 each, for the best story, article or report on any subject pertaining to "Commercial Electricity." The competition will close on Sept. 1. For full particulars address Competition Editor, Society for Electrical Development, Inc., 29 West Thirty-ninth St., New York City, and give name of employer.

Westinghouse Strike Ended—It has been officially announced by the Westinghouse companies that the Westinghouse strike at East Pittsburgh was called off by the workmen on Thursday, July 9. While the day set for their return to work was Monday, July 13, a large number of the men reported on the Friday and Saturday preceding. The works are now running full time.

Correction—In the articles describing the Hauto steam-electric power plant in the June 9, 16, 23 and 30 issues, through an inadvertence it was stated in the table of equipment that venturi meters were from the Builders' Iron Foundry Co., whereas they were furnished by the Simplex Valve & Meter Co., 112 North Broad St., Philadelphia, Penn.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Department of Electric Light and Water, North Attleborough, Mass., is in the market for water-tube boilers. William Plattner is Mgr.

Bids will be received until Aug. 4, for constructing additions to the power house and for furnishing equipment for the Norfolk State Hospital, Foxboro, Mass., an engine, dynamo and switchboard will be required. W. Rodman Peabody is Chn. Bd. of Trustees.

Bids will soon be received by the Worcester State Asylum, Worcester, Mass., for a 72-in. by 21-ft. 6-in. horizontal tubular boiler, 94 tubes, 3½-in. by 20-ft. shell ½ in. thick, quadruple buttstrap riveted for the Grafton colony.

Plans are being prepared by Ewing & Chapelle, 101 Park Ave., New York, N. Y., for the erection of a central heat, light and power plant on Mohegan Ave., New London, Conn., for the Connecticut College for Women.

Bids will be received by Franklin W. Hooper, Secy. Bd. of Trustees, 30 Lafayette Ave., Borough of Brooklyn, New York, until 10 a.m., Aug. 8, for constructing a power house for the New York State School of Agriculture, near Farmingdale, N. Y.

The Tracy Development Co., Waterloo, N. Y., contemplates constructing a power plant at Waterloo. E. K. Baldwin is Secy.

SOUTHERN STATES

Bids will soon be received for the construction of a municipal electric-light plant, Winston-Salem, N. C. I. V. Turner is City Clk.

The Georgia School of Technology, Atlanta, Ga., will construct a power plant estimated to cost $200,000.

The Axton-Fisher Tobacco Co., Louisville, Ky., is erecting a new plant in which will be included a power plant. A dynamo and several motors ranging from 5 to 30 hp. will be installed.

The Purified Petroleum Products Co., Louisville Trust Bldg., Louisville, Ky., will soon be in the market for a 20-hp. motor.

CENTRAL STATES

Plans have been prepared by Ernest McGregor, Leader News Bldg., Cleveland, Ohio, for the construction of a power plant for the Parish & Bingham Co., 5363 Hamilton Ave., Cleveland.

Bids will be received until Aug. 7 for rebuilding the electric-lighting plant and water-works at Norwood, Ohio. The estimated cost is $62,000. Two boilers, two engines, an air compressor, two generators and a switchboard will be required. Walter G. Franz, Union Trust Bldg., Cincinnati, is the Engr.

The Munising Electric Light & Power Co., Munising, Mich., will soon construct a new power plant.

Bids will be received by M. J. Keating, Village Clk., Wauzeka, Wis., until July 28, for furnishing one 10-hp. gasoline-kerosene engine and one 5x8-in. triplex power pump.

WEST OF THE MISSISSIPPI

The Des Moines Electric Co., Des Moines, Iowa, will make extensions and improvements to its power plant, to cost $160,000. W. H. Thompson, Jr., Des Moines, is Gen. Mgr.

At a recent election the citizens of Lyons, Iowa, voted to issue bonds for the construction of a municipal electric-light plant.

F. M. Newland, Comr. of Water and Light, Topeka, Kan., has applied for a new unit in the power equipment. The estimated cost is $4500. C. B. Burge is City Clk.

The construction of an electric-light plant at Pilot Grove, Mo., is under consideration.

The Cisco Gas & Electric Co., Cisco, Tex., has been organized for the purpose of constructing an electric-light plant at Cisco. W. S. Michael is interested.

The Texas Southern Electric Power Co., Houston, Tex., has been incorporated to construct a power plant at Houston. Edwin B. Parker is interested.

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POWER

Vol. 40 NEW YORK, AUGUST 4, 1914 No. 5

COMMISSION GOVERNMENT CITY OF MEMPHIS
BOILER ORDINANCE
OFFICE OF THOS. DIES
LAWS
DEPARTMENTS OF EXAMINERS OF STEAM ENGINEERS AND INSPECTION OF STEAM BOILERS
ORDINANCE
Steam Boilers
City and County of Denver
RULES AND REGULATIONS
INSPECTION OF BOILERS
RULES AND REGULATIONS FOR THE CONSTRUCTION INSTALLATION AND OPERATION OF STEAM BOILERS IN THE CITY OF SEATTLE
OFFICE OF THE INSPECTOR OF STEAM BOILERS
WILLIAM MURRAY
LAWS MONTANA BOILERS
The City of Detroit
Boiler Inspection Ordinance
Rules Formulated By The Board of Boiler Rules
Adopted by the Common Council
STATE OF OHIO
BOILER INSPECTION LAW
AND
Rules Formulated by The Industrial Commission of Ohio
FOR
The Division of Boiler Inspection
THE COMMONWEALTH OF MASSACHUSETTS
RULES FORMULATED BY THE BOARD OF BOILER RULES
ORDINANCE
POWER

[*Suggested by George B. Longstreet, Somerville, Mass.*]

Safety First

Gadsden Steam Power Plant, Gadsden, Ala.

By Warren O. Rogers

SYNOPSIS—A standby steam-power station of 10,000-kw. capacity. A feature of interest is the condenser pit, 38 ft. deep, 27½ ft. wide and 66½ ft. long, containing two 6000-sq.ft. surface condensers, two turbine-driven circulating pumps and two house pumps. Placing the main smoke flue on the power-house roof is an innovation from ordinary practice, as is the outdoor substation.

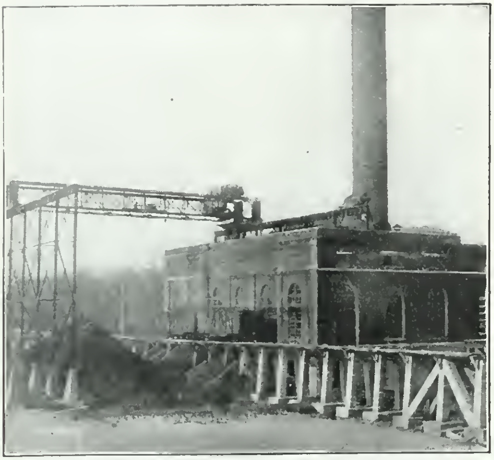


Fig. 1. Coal-Handling Apparatus and Smoke Flue on the Roof

*

The Alabama Power Co., Birmingham, Ala., recently completed and put into operation a steam-turbo-generator station of 10,000-kw. capacity at Gadsden, Ala. The company is also building, a water-power development at Lock 12, on the Coosa River, which will have a rating of 54,000 kv.a., and it has plans for constructing a high-tension transmission system which, when completed, will extend over a network of more than 800 miles, reaching to the most important parts of the state. The Gadsden steam plant, which cost about $800,000, and the Coosa River development have a total of 65,000 kv.a. for present distribution.

The steam plant is situated close to the Coosa River, about two miles from Gadsden. The building, Fig. 1, has a concrete substructure and a brick and steel superstructure.

Turbine Room

In the turbine room, there are two six-stage, 5000-kw. horizontal turbo-generators, Fig. 2. The operating floor is divided by a 13-in. thick curtain wall separating the turbine room from the pump and boiler room. Fig. 3, a plan view of the plant, shows the general arrangement of the units. The turbine room is 91 ft. 4 in. long by 50 ft.

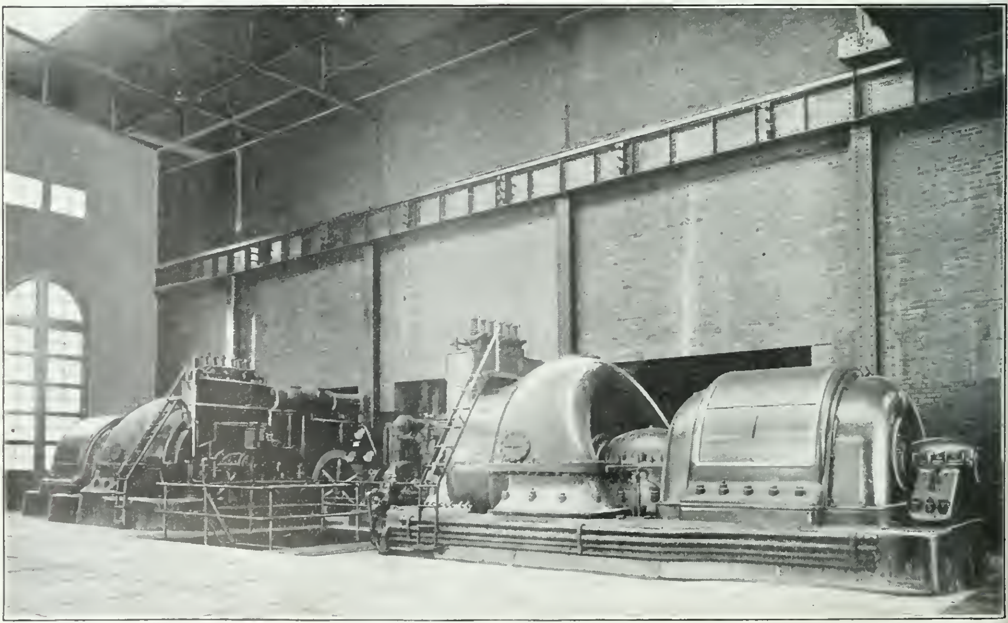


Fig. 2. Two 5000-Kw. Turbo-Generator Units

wide. The turbines are next to the curtain wall, leaving ample room for two more units of the same floor area.

Of the two exciter units, each of 100-kw. capacity, one is driven by a 150-hp. induction motor at 880 r.p.m., and the other by a 100-kw. steam turbine at 2400 r.p.m. Both direct-current generators supply energy at 125 volts. The motor-driven unit is near the switchboard, but the other is between the two main turbines and back of the condenser pit, Fig. 4.

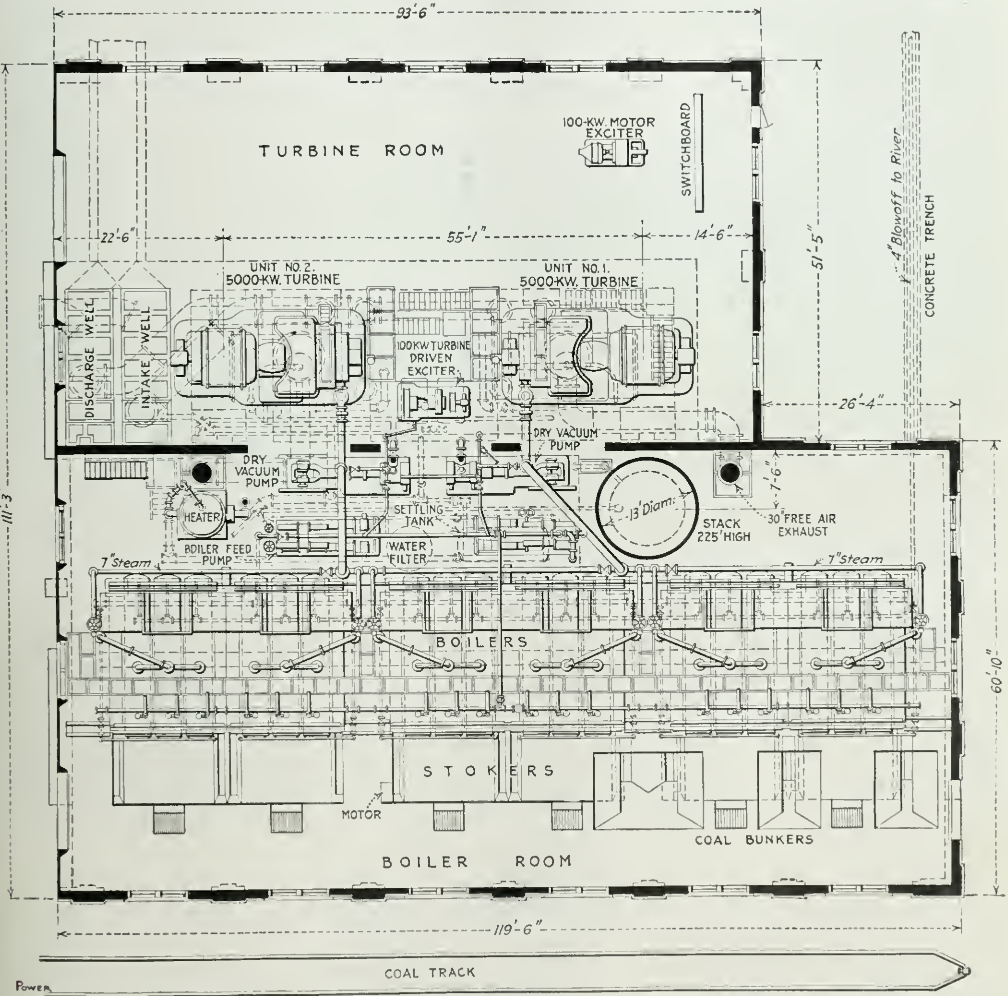


Fig. 3. Plan of the Gadsden Power Plant and Principal Piping

Condensers

Each of the two condensers has 14,000 sq.ft. of cooling surface, a total of 28,000, or 2.8 sq.ft. per generator kilowatt. They rest on I-beams set in the concrete walls of the condenser pit, which is 27½ ft. wide, 66½ ft. long and 38 ft. deep. The walls and bottom of the pit are 4 ft. thick. At the bottom, which is reached by an iron stairway, are two turbine-driven, 24-in. tri-rotary pumps, which at 900 r.p.m. supply circulating water to the condensers. Two 10- and 10 by 10-in. service pumps supply water to the tank on the power-house roof. There are also two turbine-driven hotwell, 4-in. turbine pumps.

Fig. 5 shows the arrangement of apparatus in the condenser pit. Condensers are placed in the pit under each turbine and piped to it by a 6-ft. diameter exhaust connection. The circulating water is pumped from the river to the condensers through an intake tunnel on the suction side of the circulating pump and a 30-in. discharge pipe to the condenser, at the side near the top. The discharge water flows back to the river by gravity.

Condensate from the condensers is pumped from the hotwell to a vacuum heater just back of the boilers at one end of the pump room. When there is more hot water than can be handled through the heater, which occurs

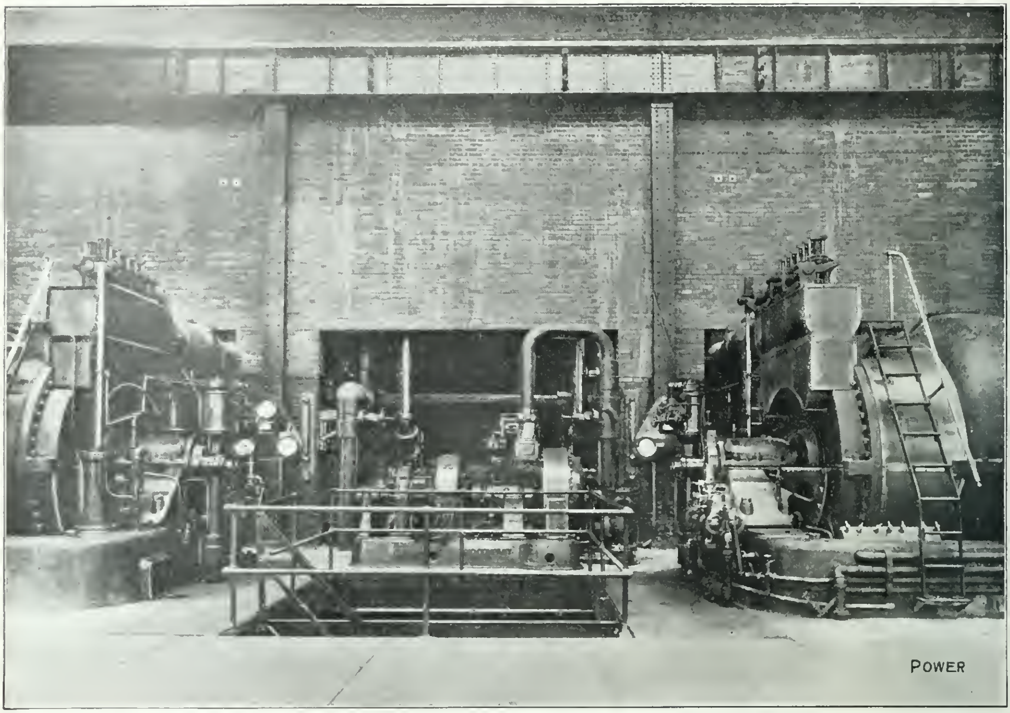


FIG. 4. CURTAIN WALL, CONDENSER PIT AND TURBINE-DRIVEN EXCITER UNIT

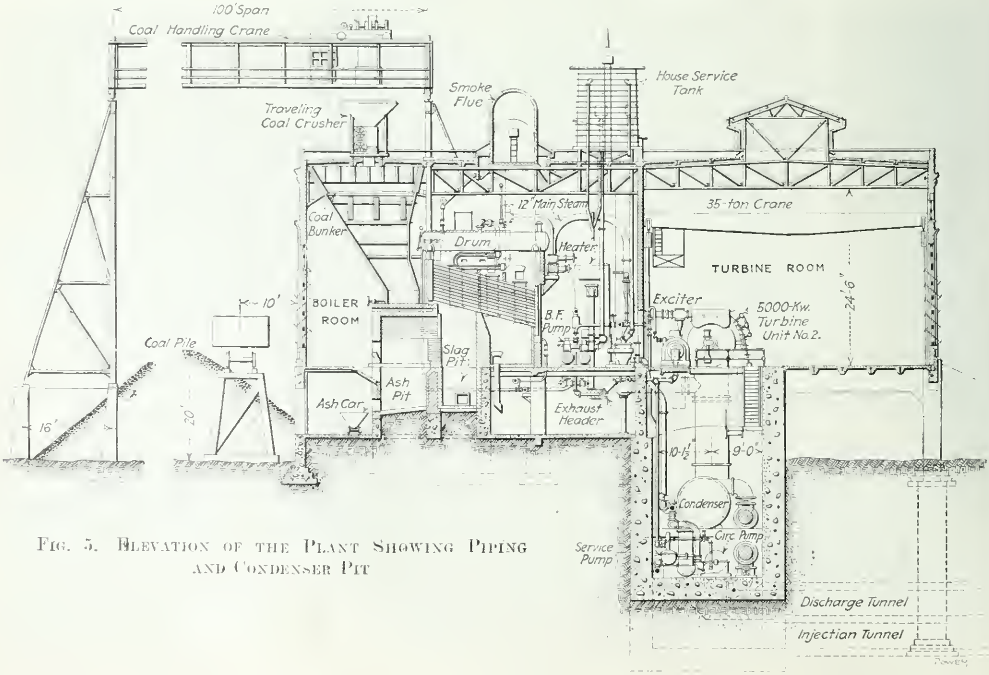


FIG. 5. ELEVATION OF THE PLANT SHOWING PIPING AND CONDENSER PIT

at certain times when there is a minimum demand for feed water by the boilers, the excess water goes to a hot-water storage tank. When the heater is working at its maximum capacity, any increase in the feed-water supply causes a float valve to open and the excess water goes to a storage tank. As the demand for feed water increases and the water in the heater falls below a predetermined level, a float valve is opened on a line between the storage tank and the condensers, allowing the hot water to return to the condensers; it is then fed from the hotwell to the heater. By this arrangement, there is no waste of feed water and hot water is always available for maximum demands. Makeup water is obtained from the house tank and the supply is automatically controlled. This water is taken from the river and passes through filters before going to the tank.

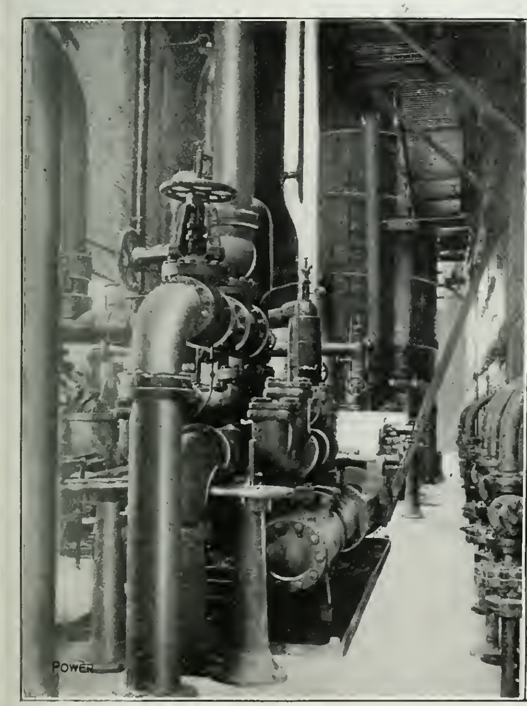


Fig. 6. Boiler-Feed Pumps and Rear End of Boilers

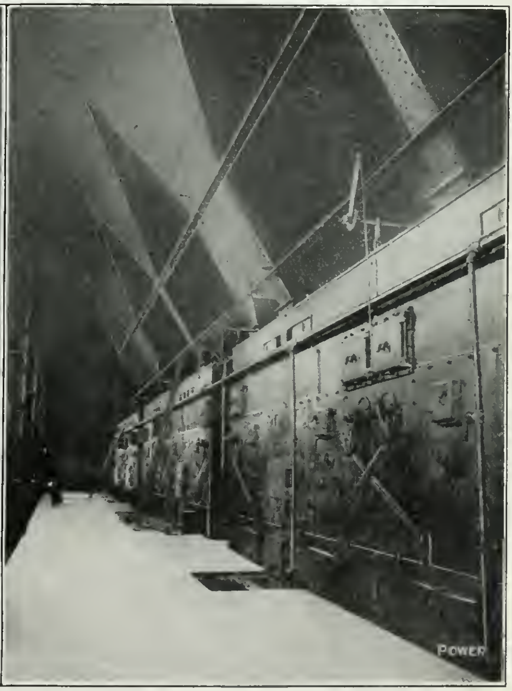


Fig. 7. Partial View of the Boiler Room and Coal Bunkers

Between the vacuum heater and the chimney are two 10- and 25- by 18-in. dry-vacuum pumps and two 18- and 10- by 18-in. outside, center-packed, boiler-feed pumps, Fig. 6. Each air pump is connected to a condenser by a 12-in. pipe. The exhaust pipe from the steam end connects with a common auxiliary 12-in. exhaust line running to the heater. The steam lines to the air pumps are 6 in. in diameter, and branch from a main 6-in. auxiliary header; the dry-air pumps also receive steam from the 6-in. header. All auxiliary exhausts are piped to a common main equipped with an 8-in. atmospheric exhaust. The turbines have a free air exhaust 30 in. in diameter.

There are six three-drum, 600-hp. water-tube boilers, Fig. 7, each with 294 four-inch tubes, 18 ft. long and placed 21 wide and 14 high. The boilers are designed for 225 lb. pressure, but only 185 lb. is carried.

The dutch-oven furnaces are equipped with automatic stokers, having a grate 12 ft. wide and 8 ft. 7 in. long, or 103 sq.ft. of surface. As each boiler has 6000 sq.ft. of heating surface, the ratio to the grate area is 58.25 to 1. The top of the furnace is 10 ft. 10½ in. above the fire-room floor, which gives an interior furnace height of 8 ft. 3 in. above the bottom of the stoker. This construction calls for a bridge-wall 9 ft. 3 in. high, with a 6-ft. space between it and the inner end of the furnace.

The 5x6-ft. smoke uptakes are at the back end of and above the boilers, each having an area of 30 sq.ft. These connect with a main smoke flue on the roof, as shown in Fig. 8. The flue is constructed of sheet steel lined with firebrick, is 12 ft. 5 in. high at the center section and 7 ft. 9 in. high at both ends, with a cross-section of 7 ft. 3 in. The outlet connects with a brick-lined steel chimney having an inside diameter of 13 ft. It is 225 ft. high above the boiler-room floor, and has a stack area of 132.73 sq.ft., or 22.12 sq.ft. per boiler. Its sectional area bears a ratio to the grate of 1 to 1.29 sq.ft. As there are 10,000-kw. capacity in turbines and 3600 hp. in boilers, there is one horsepower for each 2.77 kw. in output.

Of the several advantages in placing the smoke flue where it is, more room is had above or at the rear of the boilers, it is out of the way of piping and, although

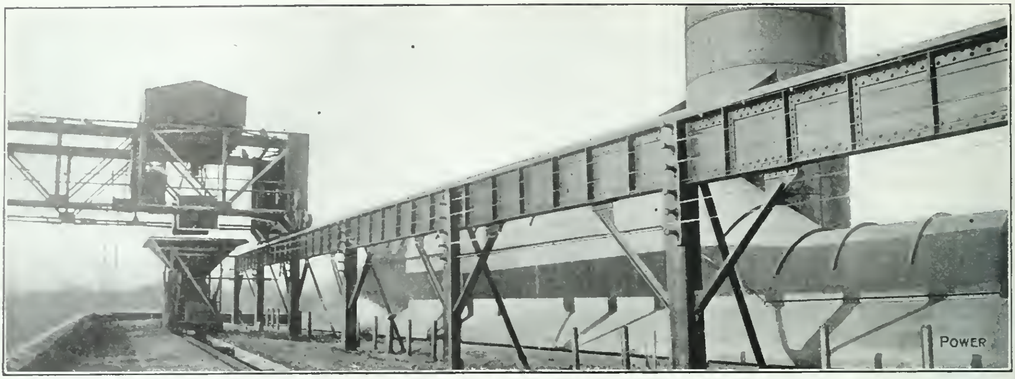


Fig. 8. Lined Metal Smoke Flue on Roof of the Boiler House, Traveling Crane and Coal Crusher

exposed to the elements the year round, this is not necessarily disadvantageous, because of the mild climate: and, being lined, the coolest weather reduces the temperature of the gases but slightly.

At the right of Fig. 8 is shown the traveling crane, which has a span of 110 ft., and the grab bucket of $2\frac{1}{4}$-tons capacity. Coal is delivered in railroad cars and dumped from the trestle, Fig. 1, into a yard with a storage capacity of 9000 tons. The grab bucket dumps the coal into an electrically controlled traveling coal crusher, which runs on rails on each side of the opening above the six coal hoppers. After crushing, the coal falls into the hoppers and is then discharged by gravity to the stokers.

The boilers are arranged in three pairs so that either set can supply steam to either turbine: in fact, the plant is laid out on the unit system.

At the rear of the boilers is the 7-in. main steam header, approximately 5 ft. below the center line of the steam drums. Saturated steam is taken from the three drums on each boiler to the superheater connection through a 7-in. pipe, the outlet pipe to the header being of the same size. A stop valve in the main header between each set of two boilers permits of cutting them out without interfering with the operation of the remaining boilers.

Above the two feed pumps is a 7-in. feed main from which two duplicate feed lines run to two 7-in. pipes. connecting two header lines of the same size, thus giving two sources of boiler feeding from either pump.

The generators are wound for 2300 volts and the voltage is stepped up by two banks of three winding transformers to either 22,000 volts for local transmission or

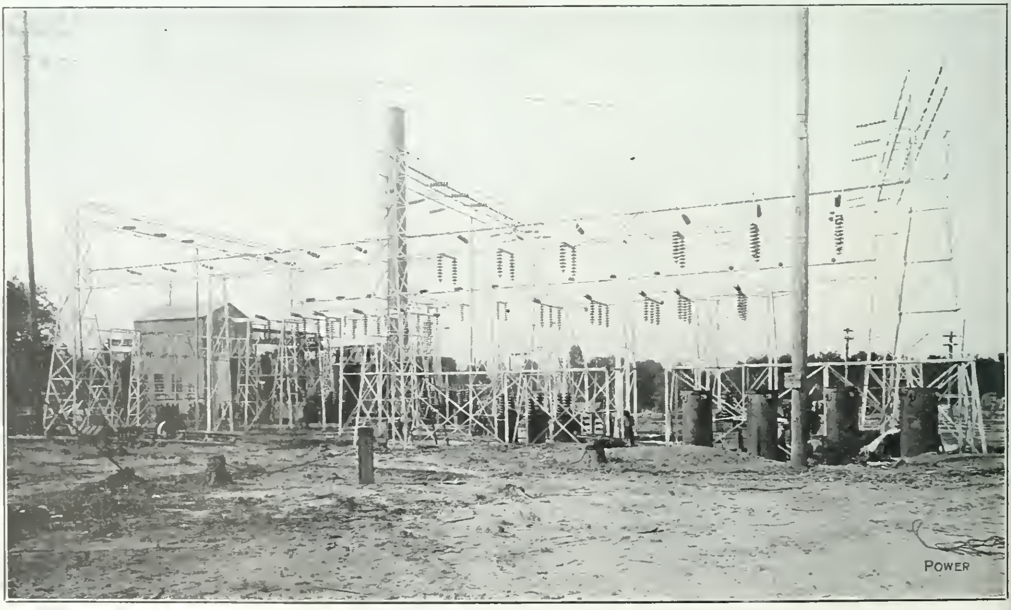


Fig. 9. Outdoor Substation at the Gadsden Plant

PRINCIPAL EQUIPMENT OF THE GADSDEN STEAM POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Steam, horizontal.	5000 kw.	Main units.	1800 r.p.m., condensing 185 lbs. steam.	General Electric Co.
2	Generators	Alt. current	5000 kw.	Main units	1800 r.p.m. 2300 v., 1570 amp., 3 phase 60 cycle	General Electric Co.
1	Turbine	Steam	100 kw	Driving exciter	2400 r.p.m. 185 lb. non-condensing	General Electric Co.
1	Motor	Induction	150 hp.	Driving exciter	880 r.p.m. 2200 v., 3 phase, 60 cycle	General Electric Co.
2	Generators	Direct current.	100 kw.	Exciter	800-2400 r.p.m., 125 volt, 800 amp	General Electric Co.
2	Condensers	Surface	14,000 sq.ft.	With main units	28 to 29 in. vacuum	Henry R. Worthington
2	Turbines	Steam, horizontal.		Driving circulating pumps	900 r.p.m., 185 lb. steam	Terry Steam Turbine Co.
2	Pumps	Tri-rotary	24 in.	Circulating pumps	900 r.p.m.	Henry R. Worthington
2	Pumps	Duplex	10x10x10 in.	House service	Intermittent	Henry R. Worthington
2	Turbines	Single stage		Driving hotwell pumps		Terry Steam Turbine Co.
2	Pumps	Turbine	4 in.	Hotwell pumps		Henry R. Worthington
1	Heater	Vacuum		Boiler feed water.	215 deg.	Warren Webster & Co.
1	Filter	Jewell		House water		New York-Continental-Jewell Filtration Co.
6	Boilers	Water-tube	600 hp.	Main steam generators	185 lb. pressure, 125 deg superheat	Babock & Wilcox Co.
6	Stokers	Mechanical.	8′7″x12′.	Dutch oven furnaces	Engine driven	Murphy Iron Works
1	Crane	Traveling	2¼ tons	Handling coal to crusher	As required	Toledo Crane Co
1	Crusher	Traveling		Crushing coal.	As required	Orten Steinberg Co.

to 110,000 volts for the high-tension distribution. The single-phase transformers, of 2100-kv.a. capacity, are of the outdoor type, as are the oil switches.

The lead-covered cables from the generators are carried through the concrete floor of the turbine room and are hung from the ceiling of the basement as far as the slate switchboard. The outgoing lines leave the station through fiber ducts laid in concrete, in three pairs of three-phase cables to the transformers at the outdoor substation, Fig. 9, about 400 ft. from the power house.

All the control switches are in the turbine room. The substation takes care of four 110,000-volt transmission lines, steps up the voltage from 2300 to either 22,000 or 110,000 volts and steps down the 110,000 volts transmission voltage to 22,000 or 2300.

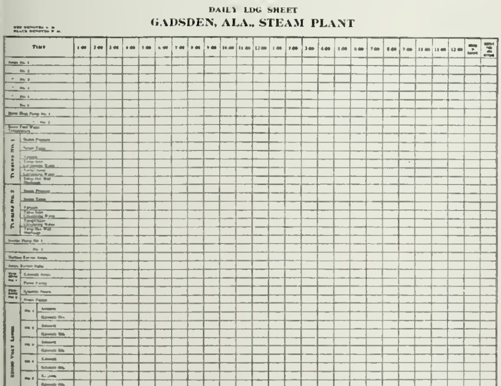

DAILY LOG SHEET
GADSDEN, ALA., STEAM PLANT
WATTMETER READINGS

Fig. 10. Daily Log Sheet

At present, this power station is used to build up the load for the hydro-electric plant at Lock 12. When this station is in operation, the steam plant will be used as a reserve and operate about 5 per cent. of the time. All 110,000-volt substations now built and to be constructed are, and will be, of the outdoor type of 3000-, 6000- or 10,000-kv.-a. rating.

As in all uptodate power stations, a record is kept of the station performance. The daily log sheet is reproduced in Fig. 10 and takes care of all items of importance.

⁂

Rivet-Set Retainer

A rivet-set retainer for pneumatic riveters is made by the Ingersoll-Rand Co., 11 Broadway, New York City. The retainer consists of a single piece of heavy spring steel, closely wound into spiral form. One end fits over the outside of the hammer nozzle and hooks over a projection integral with the nozzle. The other end is wound to a smaller diameter.

Sets for rivets over ⅞ in. in diameter are formed with a coarse thread and are simply screwed into place. Sets for rivets ⅞ in. in diameter and smaller are formed with a shoulder and are slipped into the retainer while it is detached from the hammer, the shoulder holding it in place.

⁂

Efficiency—The efficiency of a machine is the rtaio of the useful work to the total work. For example, the efficiency of a boiler is the ratio expressed as a percentage of the heat units utilized in heating the water and raising steam to the total heat units generated by the combustion of the fuel

⁂

Pennsylvania Coal Production in 1913—Pennsylvania mined more coal in 1913, both anthracite and bituminous, than in any previous year in the history of the industry, according to a statement just issued by the United States Geological Survey from figures compiled by E. W. Parker in coöperation with State officials. The production reached the enormous total of 265,306,139 short tons, valued at the mines at $388,220,933. Of this 91,524,927 tons was anthracite, valued at $195,181,127, and 173,781,217 tons was bituminous or soft coal, valued at $193,039,806. The total tonnage broke the previous record for 1912 by 19,079,053 short tons, or nearly 8 per cent., the proportionate increase being about the same for both anthracite and bituminous. The gain in the value of anthracite, however, was $17,558,501, or about 10 per cent., over 1912 and in bituminous coal $23,669,309, or 14 per cent. The total gain over 1912 was $41,227,810, or nearly 12 per cent. The combined production exceeded by more than 20 per cent. the total production of the United States in 1898, only 15 years previous. It exceeded that of any other country in the world, except Great Britain and Germany, and approached within less than 10 per cent. of Germany's output. It was nearly five times the production of the Austro-Hungarian empire, nearly six times that of France, nine times that of Russia and Finland, and ten times that of Belgium. It was equal to nearly 20 per cent of the world's total production, and exceeded the combined output of all the countries of the world other than Great Britain, Germany, and the United States. From 1829 to and including 1900 Pennsylvania contributed over 50 per cent. of the total coal production of the United States, and the State still produces between 45 and 50 per cent. of the total.

Heat--A Lecture for Beginners

By Charles H. Bromley

SYNOPSIS—A simple treatment of heat. Tells the beginner what he wants to know about heat as applied chiefly to boiler practice. Temperature, sensible and latent heat, specific heat—all are explained in the beginner's language.

⁂

As the boiler is a combined heat generator and heat absorber, an understanding of what the unit of heat is, is essential to a thorough understanding of boiler operation. Heat is a form of energy for which there are numerous explanations, but they are of little practical value to the power-plant man. One of the most essential things for him to know is that the standard quantity or unit of heat in general use in this country is the *British thermal unit* (abbreviated B.t.u.). In practice, this *quantity* is usually considered as that amount of heat required to raise the *temperature* of water one degree F.

Temperature

While the B.t.u. is the *quantity* of heat, the temperature indicates the *quality* of heat. One hundred pounds of water at 100 deg. F. contains more heat than one pound of water at 200 deg. One body of water is twice as *hot* as the other, but it did not take as much heat to make it that hot as it did to make the larger body one-half as hot; see Fig. 1. Remember that temperature indicates only *how hot* a body is; it does not tell directly *how much heat* there is in it.

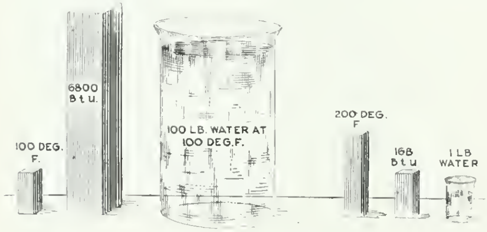

6800 B t u.
100 DEG. F.
100 LB. WATER AT 100 DEG.F.
200 DEG. F
168 B t u
1 LB WATER

Fig. 1. Showing that Temperature Is Not Alone a Direct Indication of the Amount of Heat in a Body

Pressure, of course, has a good deal to do with heat and temperature as related to water. For instance, as seen from Fig. 1, there is much more heat in the 100 lb. of water at 100 deg. F. than there is in the one pound of water which is at 200 deg. F. Suppose we had the 1 lb. of water under 400-lb. absolute pressure—that is, the pressure as indicated by the gage plus the pressure of the atmosphere or 15 lb.; the temperature would be 444.8 deg. F. The one pound of water would contain 1208 B.t.u. at this temperature—over seven times as much as when heated to 200 deg. F.

Thermometer Scales

The measurements of temperature as we make them are arbitrary. They are made to suit our convenience, as shown by the three standards in use; the *Fahrenheit* scale, which is mostly used in engineering calculations in America, and the British Isles, and according to which water freezes at 32 deg. and boils at 212; the *Centigrade,* used universally, on which the freezing point is 0 deg. and the boiling point 100, and the *Reaumur,* where the freezing point is 0 deg. and the boiling point 80 deg. We see then that

$$1 \text{ deg. Fahrenheit} = \tfrac{5}{9} \text{ deg. Centigrade}$$

$$1 \text{ deg. Fahrenheit} = \tfrac{4}{9} \text{ deg. Reaumur}$$

so that to express the different scales in terms of one another we have:

$$\text{Fahrenheit degrees} - 32 \times \tfrac{5}{9} = \text{Centigrade degrees}$$

$$\text{Fahrenheit degrees} - 32 \times \tfrac{4}{9} = \text{Reaumur degrees}$$

$$\text{Centigrade degrees} \times \tfrac{9}{5} + 32 = \text{Fahrenheit degrees}$$

$$\text{Reaumur degrees} \times \tfrac{9}{4} + 32 = \text{Fahrenheit degrees}$$

Absolute Temperature

Put a cake of ice in a room where the temperature is 20 deg. below zero and the ice will eventually *cool off* until its temperature is the same as that of the room; the ice will *give up heat* to the air in the room. We see then that, although ice forms at zero degrees on the Centigrade scale, this is not the lowest temperature that a body may attain; it is not the temperature at which there is a *total absence of heat,* not *absolute zero* beyond which it is impossible to cool a body. Neither are the zero points on other thermometers; man puts them where it is convenient, but the absolute zero of temperature is not fixed by man, Nature having established it for man to discover.

Experiments on the expansion of gases kept at a constant pressure show that the volumes and temperatures increase and decrease proportionately; the volume increasing $\frac{1}{273}$ for each degree Centigrade increase in temperature and decreasing $\frac{1}{273}$ for each degree Centigrade decrease in temperature.

This being so, we see that, *mathematically,* at a temperature of —273 deg. C. or —459.4 deg. F. (the minus sign means negative, means below zero), the volume would disappear. Experiments show that this law, called the Law of Charles, holds true within the limits which we are able to measure. In making calculations in thermodynamics it is sometimes desired to use the absolute zero.

Sensible and Latent Heat

It is important in boiler practice to know how water is affected by heat. At the temperature of 32 deg. F., water changes from a solid to a liquid or from a liquid to a solid; ice forms or melts; it is a *critical* temperature. To melt one pound of ice at 32 deg. into water at 32 deg., 144 heat units or B.t.u.'s must be applied to the ice; and, to freeze one pound at 32 deg. into ice at 32 deg., 144 B.t.u.'s must be taken out of the water. To raise the temperature of one pound of water from 32 to 212 deg., which is the boiling point at atmospheric pressure, 180 B.t.u. must be absorbed, and to cool it from 212 to 32 deg., 180 B.t.u. must be given up by the water. To cool one pound of water from 212 to 32 deg., 180 B.t.u. must be taken from the water. But, to boil one pound at 32 deg. into steam at 212 deg. will require

$$180\ B.t.u. + 970.4\ B.t.u. = 1150.4\ B.t.u.$$

Remember that this is *above 32 deg. F.* and not above the thermometer zero or the absolute zero.

Notice that the steam is no hotter than the water from which it was produced after the water reached 212 deg., although it took over 5.3 times as much heat to turn it into steam as it did to raise its temperature from 32 deg. to 212 deg.

The mercury in a thermometer placed in the water while it was being heated from 32 to 212 deg., or the boiling point, would have risen from 32 to 212 deg. You could *see* the water getting hotter: the thermometer would show that it was absorbing heat. But, after 212 deg. had been reached, and, although heat were still applied to the water, a thermometer would not show any increase in temperature even though all the water was boiled into steam, and we know that over five times as much heat was needed to make steam of the water as was necessary to get the water ready to make steam. Neither would a thermometer show that it required any heat to melt ice at 32 deg. into water at 32 deg., or to cool water at 32 deg. into ice at the same temperature.

We have just considered the two kinds of heat known as sensible and latent heat. Sensible heat was that amount of heat applied to the water to raise its temperature from 32 to 212 deg. or the temperature at which steam began to form. It was sensible—i.e., it was apparent to the senses; in this case, the sense of sight when we saw the mercury rise in the thermometer. The relative amounts of these two kinds of heat are shown in Fig. 2.

The heat required to make steam of the water at 212 deg. was not apparent to the senses, except that we could see the steam escape as it was made, but we could not detect the added heat by the aid of a thermometer or by feeling the water. The heat was latent, and that is what is meant when *latent heat of vaporization* is mentioned. It is the heat required to turn a liquid into a gas without change of temperature. To boil into steam a pound of water at 32 deg., then, requires 180 B.t.u. of sensible heat and 970.4 B.t.u. of latent heat, or a total of 1150.4 B.t.u. And this latter amount is what is meant when *total heat* or *total heat of the steam* is spoken of, as in the steam tables. *Latent heat of fusion* is the heat that must be taken from a liquid to make it solidify without change of temperature, as when water at 32 deg. F. freezes into ice.

The Mechanical Equivalent of Heat

If a one-pound weight fell from a shelf 778 feet from the ground, it would strike the ground with 778 foot-pounds of energy. This number of foot-pounds is called the *mechanical equivalent of heat*, because with a perfect apparatus it would take the same amount of energy to raise the weight up to the shelf, as it would to raise the temperature of one pound of water one degree Fahrenheit.

So, when it is desired to express heat energy in terms of mechanical energy, we have

$$Mechanical\ energy = heat\ energy\ or\ B.t.u. \times 778$$

and

$$heat\ energy\ or\ B.t.u. = \frac{mechanical\ energy}{778}$$

If a steam plant could use all the heat in the coal it received, then all of this heat would be converted into work at the engine shaft. Thus, from a pound of coal containing 14,500 heat units per pound, we would get

$$14{,}500 \times 778 = 11{,}281{,}000\ foot\text{-}pounds$$

of mechanical energy.

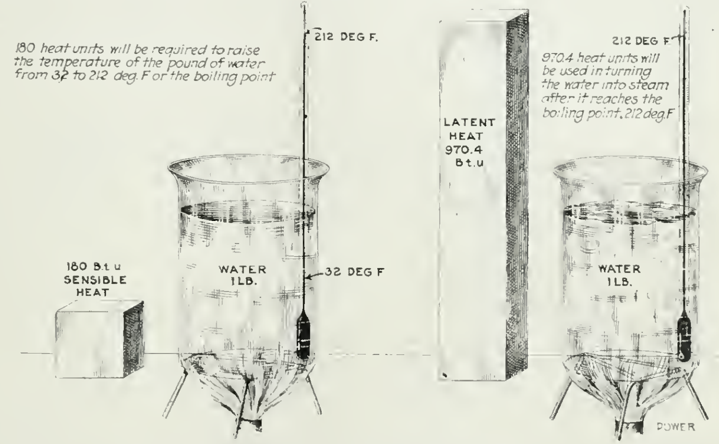

212 DEG F.
180 heat units will be required to raise the temperature of the pound of water from 32 to 212 deg. F or the boiling point
LATENT HEAT 970.4 B.t.u
212 DEG F
970.4 heat units will be used in turning the water into steam after it reaches the boiling point, 212 deg. F
180 B.t.u SENSIBLE HEAT
WATER 1 LB.
32 DEG F
WATER 1 LB.
POWER

Fig. 2. Showing the Relative Amounts of Sensible and Latent Needed to Boil a Pound of Water into Steam at Atmospheric Pressure

The plant makes use of but very little of all the heat in the coal. The boiler, if handled well, will advantageously use, say, 80 per cent., or

$$14{,}500 \times 0.80 = 11{,}600\ B.t.u.$$

Now of this the engine, which we will assume is a good compound condensing one, will turn into work, say, 19 per cent. of all the heat it receives, which in this case we assume to be 11,600 B.t.u. for each pound of coal burned in the boiler.

$$11{,}600 \times 0.19 = 2201\ B.t.u.$$

For each pound of coal burned containing 14,500 B.t.u. there is available at the engine shaft only 2201 B.t.u. The amount of heat turned into useful work multiplied by 100 and divided by the heat in the coal gives the percentage of the total available heat in the coal that was turned into work, or

$$\frac{2201 \times 100}{14{,}500} = 15.2\ per\ cent.$$

And this amount is called the *thermal efficiency* of the plant.

Specific Heat

You cannot soak up as much water with a wad of paper as with a sponge of equal volume. Neither will a granite block soak up as much as an ordinary red brick. And so on with various substances; their *capacities* for absorbing liquids are not the same.

The *capacities* of different substances for absorbing heat vary in the same way. If you put one heat unit into a pound of water, which is at, say, 62 deg. F., you raise its temperature one degree, or to 63 deg. F. If you put the same amount of heat into a pound of silver, its temperature will increase 18.1 deg. F., and for lead it would increase the temperature 33 deg.; for copper, 10.75 deg.; for ammonia, 0.99 deg., and so on, each substance having its own peculiar capacity for absorbing heat to produce a given rise in temperature. This is shown in Fig. 3. This capacity is called the *specific heat* of a substance, because that amount will produce a temperature change in a given substance that it will not produce on any other; it is specific for that substance. *Specific heat,* then, is the *heat energy required to raise a unit weight of matter 1 deg. as compared with the heat needed to raise a unit weight of water 1 deg.*

In order to compare the heat required to produce an increase of 1 deg. in some substance, we use water as a standard, for water is in common use and requires one heat unit to produce an increase of one degree; its specific heat is 1, or unity. As used in engineering calculations, specific heat is a ratio; it expresses the relation that exists between two quantities, as

$$\textit{specific heat} = \frac{\textit{heat required to raise 1 lb. of matter 1 deg.}}{\textit{heat required to raise 1 lb. water 1 deg.}}$$

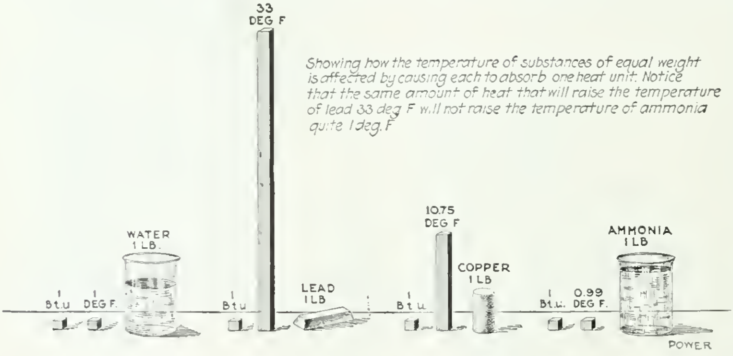


Fig. 3. Showing What Specific Heat Means

Application of Specific Heat

In engineering it often is important to know how much heat is required to increase the temperature of a substance one degree, to know its specific heat.

For example, it is desired to know how much heat is carried away by the flue gases per pound of fuel burned. The specific heat of flue gas is generally taken as 0.24—i.e., it takes 0.24 B.t.u. to heat a pound of flue gas one degree. So to find the heat lost in the flue gases, we multiply the weight of gas made by a pound of fuel by the specific heat, or 0.24, and then multiply this product by the difference in temperature between the gases leaving the boiler and the air entering the furnace. The same general method applies for finding the amount of heat absorbed or given up by any substance.

Thermofeed Feed-Water Regulator

A new design of feed-water regulator which operates solely by the water level, independently of the pressure of the steam or temperature of the feed, is illustrated herewith. The apparatus consists of the regulator, which is attached to the boiler or water column, and the regulating valve piped in the feed-water line.

The regulator is a cast-iron body with a water connection at the bottom and a steam connection near the top, at the side. A ball float on the interior is secured to toggle levers and a control valve. Above this valve is a connection with a pipe running to the top of the regulating valve. The control valve consists of a single disk operating between two seats. The valve and seats are embodied in one unit, screwed onto the stem reaching from the toggle in the float chamber to the top of the vertical spindle. The valve and seats together can be taken out for cleaning without trouble, and with the hermetically sealed spun-copper ball float, constitute the moving mechanism controlling the regulation feed valve connected to it by a ¼-in. pipe.

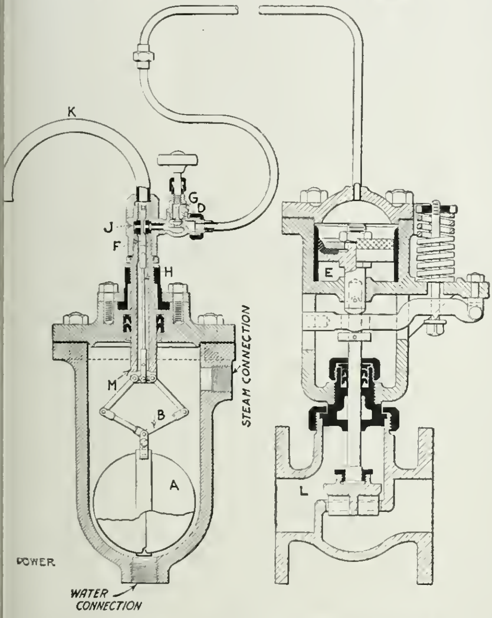
The valve *D* in the pipe connecting the regulator with the regulating valve is made with an upper and lower seat, either of which can be reached by the valve disk by turning the spindle anti-clockwise, that is, to the left, or clockwise, to the right. In the first case, steam communication from the float chamber to the regulating valve is obtained, and in the latter the regulating valve is put in communication with the atmosphere and is, therefore, out of control.

This valve must always be on one or the other of the seats and not in an intermediate position. The illustration will show how it operates. When the double valve is on the upper seat, the cylinder *E* is put into communication with the control valve *F*, and the thermofeed is in commission; when the double value is on the under seat, the cylinder *E* is in connection with the atmosphere through the vent *G*. This puts the regulator out of action and leaves the automatic flow-regulating valve open. The double-seat valve *F* performs the main function of the apparatus and is attached by a rod *H* to the float through toggle levers so disposed as to reverse the direction of motion. Any movement of the float is diminished as 10 is to 1, and the motion is transmitted through the toggle and the rod to the valve ***F***.

If the water level and the float fall, the valve ***F*** is moved to its lower seat, closing any exit of steam through it and simultaneously putting the cylinder *E* in direct communication to the atmosphere by way of the ports in *J* and the exhaust pipe *K*. If the water leve and the float rise, the valve *F* is pulled downward on it upper seat, thus permitting the passage of steam throug the lower valve onto the piston in the cylinder *E*, an in this way gradually depressing the main regulatin valve *L* onto its seat. The controlling mechanism in th loat chamber is attached to the sleeve M and can be aised or lowered by turning a nut when in action, thus ermitting of adjustment for any permanent water level.

The relay or controlling valve is far removed from the vater level, and no dirt or sediment can reach it. The vorking parts are all of non-oxidizable metal.

This regulator, which is being introduced in this counry by the American Steam Gauge & Valve Manufacturing Co., Boston, Mass., is designed to maintain a uniform level with a variation not exceeding $\frac{1}{4}$ in. for a water-tube boiler, and to give a practically constant feed.



Details of Thermofeed Feed-Water Regulator

The piston of the regulating valve is packed with S. E. A. ring rubber and asbestos composition packing, as is also the stuffing-box between the water valve and the upper part of the regulator. The spring on the outside of the piston E is adjustable, and made in square sections of cast steel.

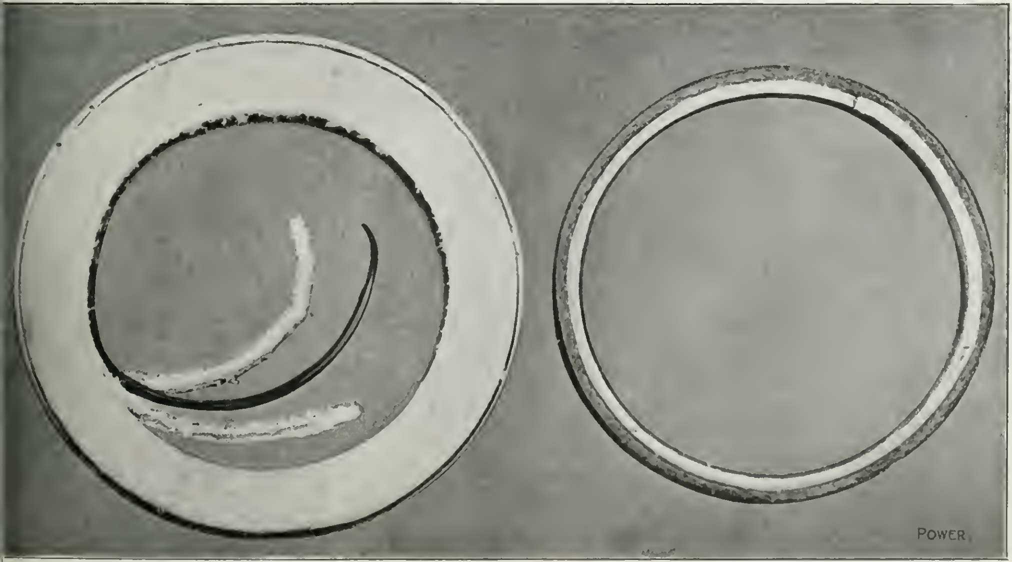
*

Flexitallic Flange and Tube-Cap Gaskets

The illustration shows two types of gasket, one suitable for flange joints and tube caps, the other for water-tube boiler caps only. The flange gasket is made up of plies of waterproof asbestos and monel metal, built up at right angles to the line of pressure in one interlocking length, beginning on the inside and ending on the outside of the gasket. This construction, shown at the left of the illustration, eliminates the possibility of the gasket blowing out, it does not stick to the flange surface, and it can be used with superheated steam, water, oil, gas, air, ammonia, acids, chemicals, etc.

This gasket, made by the Flexitallic Gasket Co., Real Estate Trust Bldg., Philadelphia, Penn., is guaranteed to stop all leaks and to remain tight when used with rough surfaces or on pipe lines subject to vibration. When once in place there is no following up, because the gasket takes care of the expansion and contraction and can be used over and over again.

Another kind of tube-cap gasket is made of metal and waterproof-treated asbestos in the shape of a reversed S. The length of treated asbestos is placed in the space formed by the curved ends, which are beaded over the asbestos. The completed gasket is shown at the right of the illustration and is to be used but once.



Flexitallic Gaskets for Pipe Flanges and Boiler Caps

Department No. 8 and Special Furnaces[*]

By Osborn Monnett[†]

SYNOPSIS—A brief outline of the construction and the principal dimensions of the settings.

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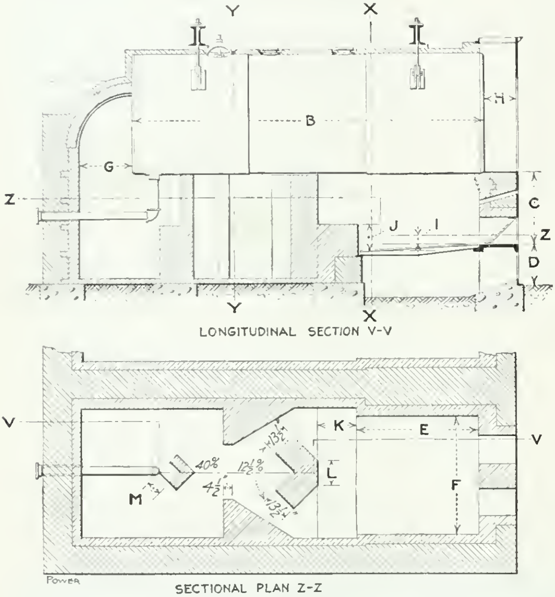
One of the latest furnaces perfected by the Chicago Department of Smoke Inspection is shown in Fig. 1.



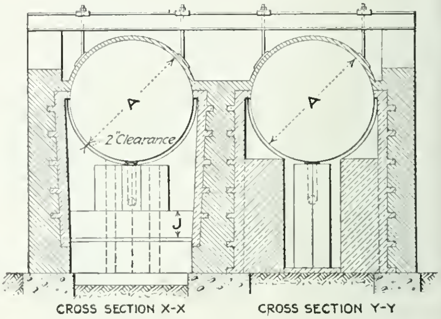


Fig. 1. The Department No. 8 Furnace

It is known as No. 8 and is of simple construction, consisting of a V-pier extending from the bottom of the combustion chamber up to the shell of the boiler and has two wing walls tied into the side walls of the furnace. The gases are thus deflected twice against hot brickwork and squeezed between the two wing walls before they pass to the combustion chamber. In this way the gases are thoroughly mixed and the temperature is found to be high enough for ignition even without arches. The steam jets and panel doors are the same in this furnace as in the double-arch, bridge-wall furnace described in the issue of July 28, 1914. It will be noticed that the side walls contain no air space; they are made solid to conform with the latest practice.

In this furnace an area of 25 per cent. of that of the grate surface should be allowed over the bridge-wall; 12½ per cent. of the grate area should be allowed for each gas pass around the V-pier. The free opening between the wing walls should be not less than 40 per cent. of the grate surface. These proportions give a furnace which works satisfactorily for ordinary power loads.

The McMillan furnace, shown in Fig. 2, is a proprietary furnace corresponding with the ideas previously advanced. It consists of a single-span, firebrick arch, which extends from the back edge of the bridge-wall forward, covering half the grates. Back of the bridge-wall is a V-pier and wing walls which mix the gases much in the same way as the No. 8 furnace. The furnace is equipped with panel doors and has in addition to this a special series of air-admission ducts along the side of the furnace from the front extending back to the bridge-wall. This air admission is controllable by dampers in the side walls and can be adjusted to meet the conditions. The dimensions given in the drawings apply only to a 66-in. by 16-ft. boiler.

Twin Fire Arch

Another patented furnace which has been successful in running without dense smoke is the twin fire-arch furnace shown in Fig. 3. This furnace, with the two just described, provides for direct radiation of the heat into the boiler and a high-temperature zone over the bridge-wall, with a deflection arch as before. The peculiarities of the furnace are as follows:

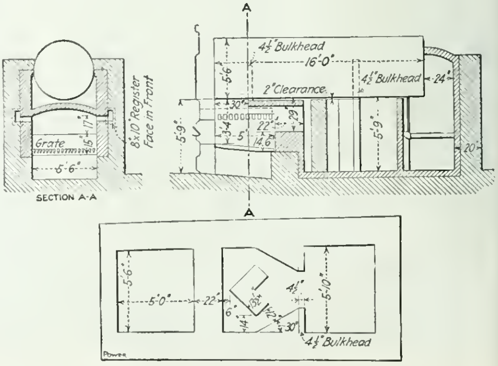


Fig. 2. The McMillan Furnace

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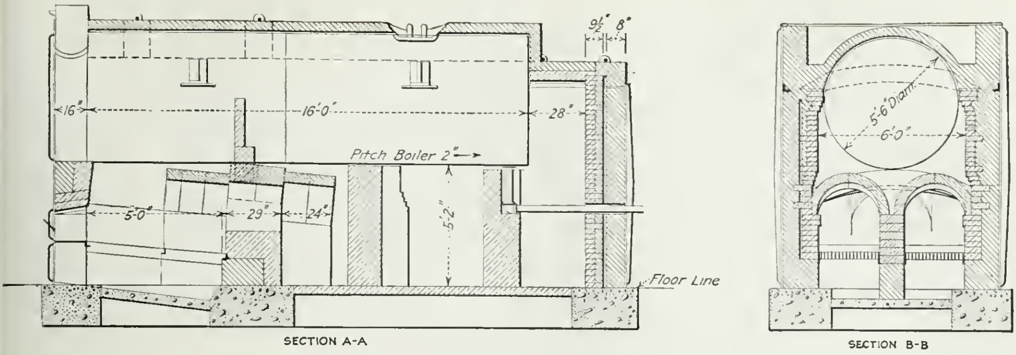
[*] Copyright, 1914, by Osborn Monnett.
[†] Smoke inspector, city of Chicago.



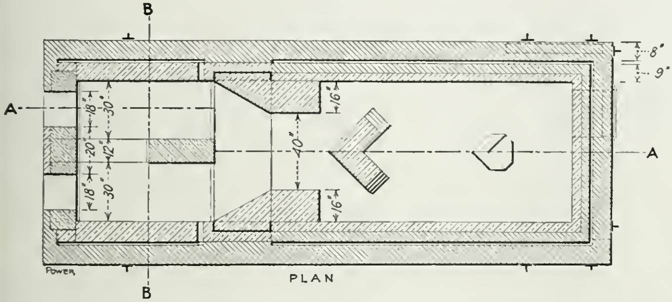


Fig. 3. Twin Fire-Arch Furnace

Starting with the fire-doors, which are equipped with panels according to the latest specifications, the grates are of the rocking-shaking type, and the arches over the fire are in two spans, or of the twin fire-arch type. Over the bridge-wall there is a single-span arch with a wing-wall construction which contracts the flow of gases as they emerge from the twin arches. The gases next come in contact with the V-pier and are thoroughly mixed. A double-span arch was formerly used in place of the V-pier, but the former kept the gases away from the shell.

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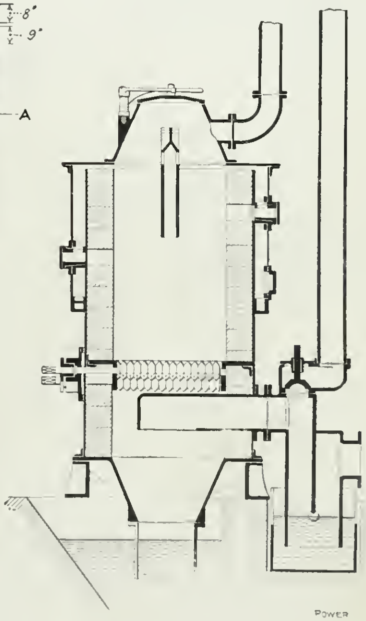
Producer for Burning Refuse and Low-Grade Coals



Section through Producer

The illustration shows the Kynoch suction-gas producer now used extensively in Australia and New Zealand, where there is an abundance of cheap wood and low-grade coals.

It is of the down-draft type, with a jacket from which heated air is drawn into the fire through special auxiliary air ports. The fuel in the upper part of the bed is partly burned, giving off its volatile constituents. The extra air drawn in through the ports creates an intensely hot zone in the fire, and as the gas containing the volatile matter from the partly burned fuel is drawn through this hot zone by the suction of the engine, the tar is split up, thus eliminating the necessity of a mechanical tar extractor. The auxiliary air ports are adjustable, so that the required extra air can be regulated to suit the quality of fuel and load conditions. The fuel is fed from the top, no hopper valve being necessary, and the condition of the fire can be kept under constant observation.

Recently a series of full-load tests was carried out on wood and other fuels obtainable in Australia, the fuel burned per horsepower-hour being reported as follows:

	Per Horsepower-Hour, Lb.
Salmon gum	2.3
Mulga scrub	2.2
Box blocks	2.15
Jarrah sawdust and shavings	2.40
Collie coal	1.2
Brown coal (16 per cent. moisture)	1.8
Spent tan bark	3.13
Pine shavings and blocks	2.31

Considering that the majority of the above materials are of low price, and in some cases are simply waste products, the economy in operation is evident.

Testing for Open Circuit

By F. A. Annett

An open circuit in the field coils of a motor may produce several different effects, depending upon the condition under which it occurs and the type of motor. If series wound, the motor cannot start, for the field winding is in series with the armature, as will be seen by referring to Fig. 1, where the field coil C is open at X and no current can flow through the motor.

In the shunt motor the field and armature windings form two independent circuits; therefore an open-circuit in the field coils will not interrupt the current flowing in the armature; see Fig. 2. In this type of machine a break in the field circuit may produce any of the following effects: The motor, if not loaded, will start if the brushes are not set at the neutral point. The direction of rotation will depend upon the setting of the brushes, but the motor will race and spark, and if an attempt is made to cut out all the starting resistance, the fuses will blow, or the circuit-breaker will open and there is likely to be burning at the commutator and brushes. If the machine is loaded, it will not start, and if the starting resistance is cut out, the fuses will be blown. With the brushes set on neutral, the machine will not start, but if they are given a backward lead, the armature will turn in the opposite direction.

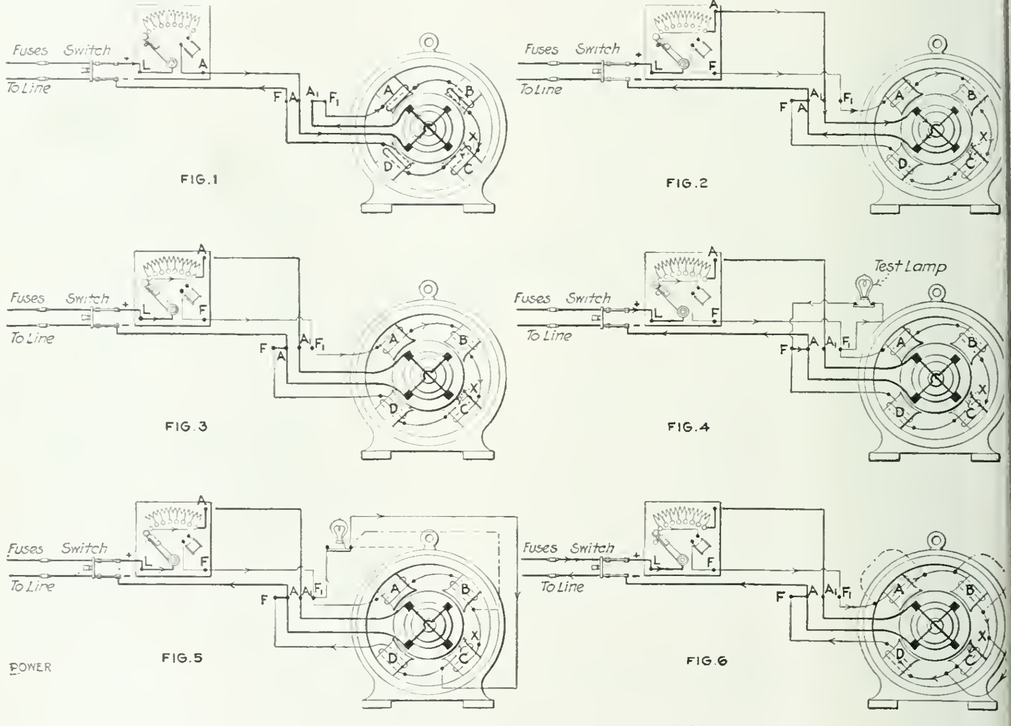


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6

How to Test for Open Circuit in Field Coils

A simple method of testing for an open field where shunt or compound motor has been operating proper and suddenly develops trouble is: First, disconnect t armature connection on the starting box, as shown i Fig. 3, and move the starting handle upon the first co tact. If the field circuit is complete when the arm is a lowed to drop to the off position or the switch is opened, severe spark will occur at the contact; if the field circu is open, there will be no spark. The break in the fiel circuit may occur anywhere from the first contact on t starting box around to the line connection on the motor. After determining that the field circuit is open, it is necessary to find out whether the break is in the motor, th external wiring, or the starting box.

A test may be made for a break in the external circui by opening the armature connection at the starting box placing the arm on the first contact, as before, and connecting a lamp across the field connection on the motor as in Fig. 4. If the lamp lights, the field circuit outside the motor is complete, as indicated by the arrowheads.

After it has been found that the break is in the field winding, inspect the connections between the field coils to see that none is broken or loose. After these are found to be in good condition, the defective field coil may be located as shown in Fig. 5. Place the starting-box arm on the first contact and connect one terminal of the test lamp to one of the field terminals of the motor; in this case to F_1. With the other lamp terminal make connection between coils *A* and *B*, as indicated by the dotted line. In this position the lamp will not light for the circuit is open at *X* in coil *C*. Next connect the free lead of the lamp between coils *B* and *C*, also indicated by the dotted line; again, it will not light. However, when connection is made between coils *C* and *D*, as shown by the solid line, the lamp will light, for now the open coil has been bridged. Since the lamp will not light between coils *B* and *C* but will light between coils *C* and *D*, it shows that coil *C* is open-circuited. Where a test lamp is not at hand, a piece of wire may be used to bridge one coil at a time, as shown in Fig. 6. First, short-circuit one coil as indicated by the dotted line at *A*, then close and open the switch. If a spark occurs when the switch is opened, the open coil has been bridged. In this case, however, it does not occur until coil *C* has been short-circuited, as shown by the full line. After the open coil has been located it should be disconnected and again tested through with a lamp to be absolutely sure that it is defective.

The open circuit often occurs where the leads are connected to the coil winding; this may be easily located and repaired. After the coil has been opened up it should be tested back of the splices where the coil connects to the leads to make sure that the trouble is in the coil itself. In many cases, especially where the coils are not wound on a spool, the open-circuit can be located and repaired without rewinding the coil, for if not found at the points mentioned, it usually can be located in the coil itself by a burned spot on the insulation caused by arcing when the coil opened.

An open-circuit in the shunt field of a compound motor will have practically the same effect as in the shunt motor, except that the motor will usually start whether loaded or not, as the series field will provide sufficient torque to start under full load, but the machine will usually race in either case. The break in the shunt field may be located in the same manner as described for the shunt machine. An open-circuit in the series field will cause the machine to fail to start in the same way as described for the series motor in Fig. 1.

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Oils and Lubrication--I

By L. D. Allen*

SYNOPSIS—Selecting an oil; its value as compared to grease, tested and filtered oils, Pennsylvania and Southwestern crudes; simple engine-room tests and specifications of oils for different uses.

⁂

"If the salt has lost its savor, wherewith shall it be salted?" This briefly illustrates conditions as to quality that seem to have prevailed to a considerable extent in the oil and grease business. If the lubricant has lost, or rather had taken from it, its oiliness, wherewith shall it be oily? The man who pays the bills usually knows little, outside of shop reports to the effect that "it seems to be all right," concerning the economic qualities of the lubricants for which he is paying. His caution seems to have stopped with having made up his mind that so long as he receives no complaints he will not consider other propositions offering a higher grade of lubricant at the same price he has been paying, or the same quality that he has been using at a lower cost. It not infrequently proves that a better grade at a higher price is, in the end, the most economical.

There is really little that the small user can do other than depend on the experience and reliability of the party from whom he purchases his oil. In the engine rooms of many small plants, however, there are men in charge whose long experience in the use of lubricants enables them to judge closely as to whether they are getting good results. In the case of large consumers it is different. Here, practical shop tests can be conducted with a view to reducing friction and conserving horsepower to an extent compensating the time and outlay. As new materials are constantly being developed, and as a knowledge of their manufacture and uses is constantly increasing, the conclusions of any one test should not be considered final. The tests should be repeated from time to time when conditions seem to warrant it.

Selecting an Oil

Standards are constantly changing so rapidly in some lines that the ideas and specifications of a year or two ago must be modified, or perhaps discarded for something different. Up to within the past two years it has been customary to judge the quality and bearing value of oils by their gravity, flash, fire, cold and viscosity tests. Crudes, however, with their different general chemical and physical characteristics, are being produced in different sections of the country that now prove the purchase of oils on a specification basis to be unreliable. In other words, due to changes in the oil industry, and the properties and characteristics of new crudes, the old specification methods are becoming obsolete and cannot be depended upon to give the buyer proper values for his particular bearing requirements. Information as to gravity, flash, fire, cold and viscosity tests is not without value, however, in comparing oils produced from the same crudes.

With this new order of things in the oil line comes a revival of the old adage that "The proof of the pudding is in the eating." The real value of a lubricant should now be determined by what it shows in the plant where its use is being considered. These requirements are:

The oil must show sufficient body to keep the bearing surfaces apart at the load, speed and temperature at which these bearings run. It is desirable to know how low a coefficient of friction it shows compared with another oil in the same bearing and under the same conditions. The flash point must be sufficiently high to meet the temperature requirements of the bearing, otherwise, reduced lubrication and loss by evaporation is the result. The oil must show proper lubricating fluidity at as low a temperature as it will be compelled to work under. It should show no tendency to decompose or to form deposits or gummy conditions, and it must contain no ingredient that will corrode or pit the bearing surfaces. The oil should be bought from a source that will insure maintenance of the standard adopted.

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*Antifriction specialist, Chicago, Ill.

Few consumers are aware that practically all of the oil and grease dealers, and many so called refiners and grease manufacturers, are really securing the most, if not all, of their products from a few large refiners, although many of these refiners are in direct competition with some of the dealers who purchase their products. It is a wheel within a wheel. The oil and grease user is likely to obtain the same oil, but under a different name, from any one of several concerns soliciting his patronage. On the other hand, the consumer would err if he did not give to each solicitor reasonable attention, courtesy and consideration. A little friendly attention often inspires a solicitor to offer a prospective customer values that he knows should retain that friendship, and at a cost sufficiently low to minimize competitive assaults. Sentiment, when it is mutual, invariably profits both the buyer and the seller.

A noted English authority—matters of this sort seem to be receiving more attention abroad than here—has found that over half of the ten million horsepower in use in England is lost through unnecessary friction, faulty lubrication and inferior lubricants. In factories in this country, where oil and grease bills amount to thousands of dollars annually, experts have found a loss of 50 per cent. or greater. There is serious effort on the part of oil, grease and babbitt manufacturers to coöperate with the trade in effecting economies along these lines, but it is too often construed as a selling rather than a helping effort.

Each Plant an Individual Problem

The writer does not claim to be an expert on oil and greases, nor does he know of any one who may be rightly so considered, for the reason that those longest in the business are conversant with so many exceptions to what at first appeared to be the rule that they refuse, where they have any real regard for their reputation for veracity, to be specific or definite in their recommendations. They know that grades and qualities which work out perfectly in some cases have proved entirely unsatisfactory in others where the conditions seemed exactly the same.

Suppose a man were something of an expert in the manufacture and use of oils and greases, he might be comparatively ignorant on bearing design and construction and on the nature of the material, brass, bronze or babbitt with which bearings are lined, and the suitableness of the method of lubrication for his lubricant in connection with the bearing conditions might escape his attention. Poor, improper or inadequate bearing design or construction is a fruitful source of babbitt and lubricant trouble. The bearings may not be large enough or of the design best for the load and conditions under which they are compelled to work. Lubricating devices may be sold without regard to the kind of bearing, load or conditions. In babbitt and lubricating problems each plant has its individual solution. Babbitt and lubricant manufacturers are more often than otherwise unjustly blamed for troublesome bearing conditions. In ninety-nine cases out of a hundred the fault will be found in improperly designed bearings, in the method of applying and handling the babbitt or lubricant, in the conditions under which they are compelled to work and the attention they get while working.

What is needed is not so much better products as better relations and understanding between the producers and the consumers themselves. Any deal that is not profitable to one is not profitable to the other. The bargain that yields mutual satisfaction is the only one likely to be permanent. The losing customer is the lost customer. The keynote of modern commerce is service.

Some consumers will say that they are well satisfied with the quality and service they are getting, but that they object to being charged an exorbitant price. An old and experienced salesman remarked sometime ago that no one is more responsible for high prices than the consumers themselves. While many appreciate the advantages, yet not enough will buy through letter solicitation. They require that the producer spend thousands of dollars in selling his product. The result is, an article that the consumer figures can be produced for 10c. has really cost the producer 15c. to sell, and he must add another 5c. for his profit. If sold by mail or by advertising the oil might have cost 15c. instead of 20c.

Having factory or engine-room tests made by an experienced lubricating engineer, under the supervision of the plant engineer or millwright, is the proper course for the large consumer to determine what is best for his specific and general requirements. The small consumer must depend on the reputation of the concern from which he is buying, on the selling argument of the solicitor, on testimonial letters, orders, etc.; from other users who are buying the oil under consideration for practically the same kind of machinery, and on such return and refund clauses, in the event the oil does not suit, as he can incorporate in his buying agreement.

The matter of suitable lubrication is quite simple if pure oils from the same crudes are obtained. A quantity each of good motor oil, a good machine oil and a good steam-cylinder stock with a few pounds of tallow, contain the essentials for a wide range of bearing requirements. While there are innumerable brands on the market, yet, with few exceptions, a half dozen oils will cover all general lubricating requirements.

In one case, nine different brands of cylinder oil, five brands of machine oil and a dozen or more different greases were in use. Some were fairly reasonable in price; others inordinately high. In one engine room the engineer needed a certain kind, in other engine rooms in the same building the engineer could not use it; he required something different. For the electrical machinery, another brand was wanted, and in the pump house the operators had their own ideas. A few simple tests were made which convinced the men that one grade of cylinder oil and two grades of engine and machine oil filled every need. It was also proved that but three grades of grease were needed.

Oil vs. Grease

As to the value of oil compared with grease for lubricating purposes, there is a wide difference of opinion. There are some facts, however, that have been quite definitely determined and generally agreed on. As a lubricant there seems to be but little real difference between the use of a pure, properly refined petroleum oil and a pure properly made oil grease. For tightly keyed journals under high speed and heavy pressure, oils seem to have the preference. The flow and spread are more abundant, so that the frictional heat is conducted away more rapidly. There is less likelihood of acids and gummy conditions in the use of oils, and they can be secured in greater variety as to density. When it comes to slow-moving machinery where the pressure is not great, the practice is in favor of greases.

Of some of the new oils now being produced from various Southwestern crudes, viscosities on straight oils range from 500 to 1000, with gravities as low or lower than have heretofore prevailed on 200 to 300 vicosity lubricants. Their values as compared with grease for the class of machinery referred to remains to be determined. The economy and service in the use of either depend on the bearing conditions, the method of applying, attention, etc.

Grease is admittedly less wasteful; it stops running when the journal stops. However, as grease is more dense or gummy, more power is required in starting, and as sufficient frictional heat must be developed to transform the dense grease body into a fluid oily state, it would argue a loss of power in this process. The re-use of oil gradually diminishes its lubricating properties, and, unless perfect filtration is secured, it must deteriorate in becoming charged with minute foreign substances. Greases containing free acids are injurious to certain kinds of bearing surface and start corrosion and wear. Oils loaded with adulterants containing rosin oil, soap preparations, blown rapeseed oil, etc., while they apparently serve their purpose fairly well, are, due to their gummy nature or acid content, either creating a drag on the journal, thereby wasting power, or are disintegrating the surface of the babbit bearing and heating the journal sufficiently to require the excess use of oil, to say nothing of the expense of rebabbitting oftener than necessary.

TREATED OILS

The quality or lubricating body of a pure petroleum oil depends on the quality of the crude and the method of refining. The filtered oils are free from those fatty acids that injure bearing surfaces. The trouble usually occurs with the treated oils. Oils filtered through fuller's earth and boneblack contain the lowest percentage of free carbon. It is usually the oil treated with sulphuric acid that affects the surface of bearing metals. In the purchase of oils it is impossible, regardless of one's experience in the oil business, to determine a filtered oil from an acid-treated oil. This can be distinguished only through tests that show ash determination. A filtered oil will show from 0.001 to 0.002 of 1 per cent. of ash, which is usually iron oxide, whereas an acid-treated oil will show from 0.5 to 0.07 of 1 per cent. of ash, usually sodium sulphate, sodium carbonate and iron oxide.

It is the high temperatures that cause oils to decompose, and, naturally, those treated by acid decompose more readily, increase in acidity and pit the bearing surfaces; also, when oils decompose, the fluid or intermolecular friction increases.

One of the most exacting duties of the refiner is said to be the treatment with caustic soda in such manner as to remove all acid products without overdoing the matter and producing an emulsion. In acid-treated oils it is necessary to wash them with caustic soda to neutralize the acidity. It has been proved that it is impossible to wash out entirely the mineral salts formed during the treating process. Tests of oils treated and then filtered through fuller's earth and boneblack show a higher percentage of ash than those that were only filtered. This brings out the point that it is impossible to obtain an oil of the highest lubricating qualities by treating it with acid. The presence of free alkali, sodium sulphate or sodium salts of organic acids are injurious to metallic surfaces. They start corrosion on the surface of the babbitt lining and shortly the result is a rebabbitting expense for which the babbitt often is, but should not be, blamed. Babbitt compositions of tin, lead and antimony resist the influence of these acids better than bronze bearings, the heavier content of bronze bearings being copper.

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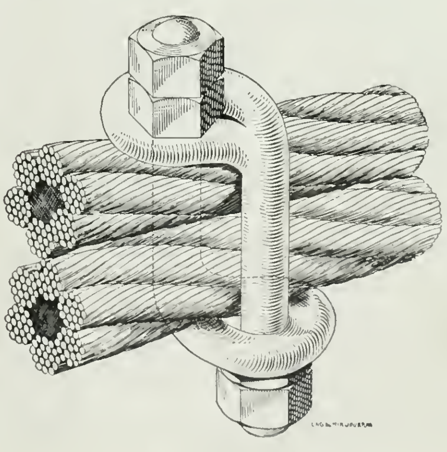
Home-Made Cable Clamp

By WALTER R. HODGE

The chief virtues of the clamp illustrated here are simplicity of operation, ease of fabrication and tenacity of grip. An ordinary blacksmith can easily turn out a dozen an hour.

For ¾-in. cable, the clamp is made of ⅜-in. iron bent into a 1¼-in. eye and welded. A shank 3 in. long is threaded half its length and turned at an angle of 90 deg. to the plane of the eye and two nuts are provided for each shank. The clamps are used in pairs, the shank of one being shoved through the eye of the other with the two thicknesses of cable between and the nuts placed and tightened and locked with the extra nuts.—*The Engineering & Mining Journal.*



APPLICATION OF CABLE CLAMP

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The Word "Zero" is from the Spanish, and means empty, hence nothing. It was first used for the thermometer in 1795 by the Prussian merchant and physicist Fahrenheit.

Air Compressors Driven by Keokuk Power

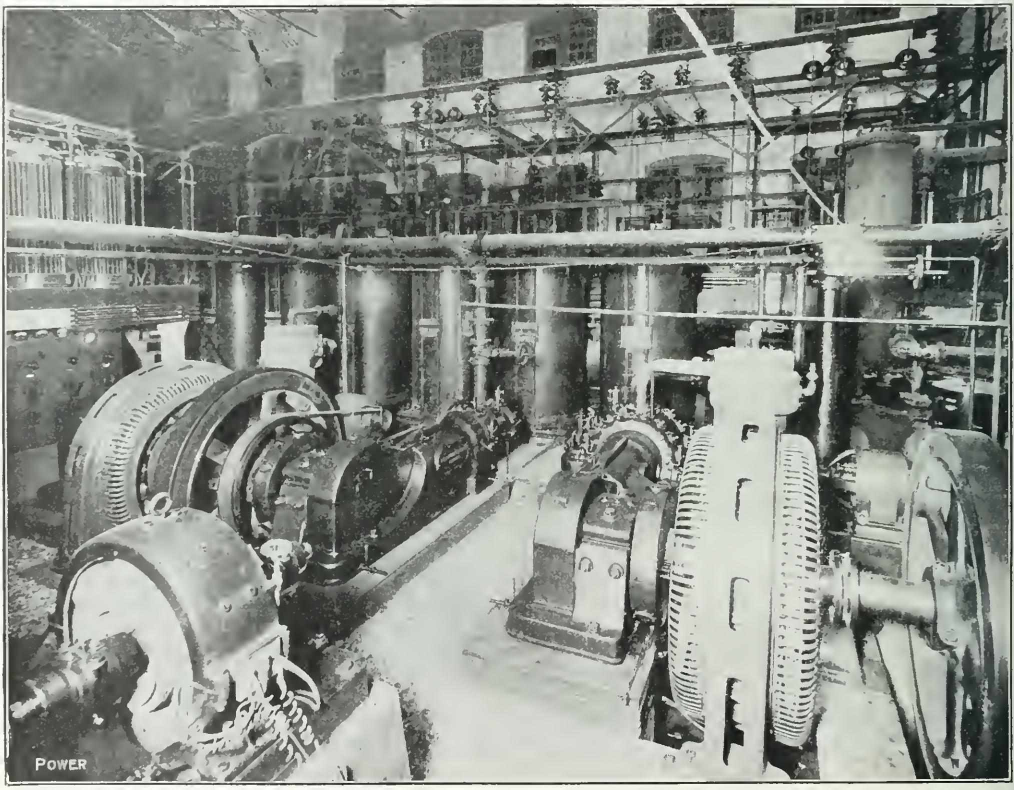
SYNOPSIS—One of the first private plants to be operated by power from the Keokuk power plant is that of the Atlas Portland Cement Co., Hannibal, Mo.

In August, 1913, the steam-driven air compressors of the Atlas Co. were replaced by three Sullivan cross-compound air compressors, with 26 and 15¼ by 18in. cylinders, each machine having a capacity of 2000 cu.ft. of free air per minute. These compressors are directly connected to General Electric 400-hp synchronous motors, running at 187.5 r.p.m., using three-phase, 25-cycle, 220-volt current, stepped down at the transformer station from a voltage of 33,000, at which tension it is transmitted from the Keokuk plant, on the Mississippi River, about sixty miles distant.

An average receiver pressure of 100 lb. is maintained by means of total-closure unloading valves on each machine. These unloading valves are operated automatically, so that a 5 per cent. regulation is obtained in receiver pressure.

To supply the present demand of the plant, the energy input to the compressors will average about 12,000 kilowatt-hours per day. The principal use for this air is found in a blast supplying pulverized coal to rotary kilns and for drills in the limestone quarry. Air is also supplied to the machines in the blacksmith shop for operating hammers, hoists, drills, etc., and there are outlets at convenient points throughout the plant for cleaning motors and other apparatus.

This installation was made by the Stone & Webster Engineering Corporation, of Boston, and is the first large compressor plant of its kind operated by power from the Keokuk plant.



Air Compressors, Motor Driven by Energy from the Keokuk Power Plant

The illustration shows the motors directly connected to the crankshaft of the compressors. The large step-down transformers for the compressors and for other purposes in the works are shown at the rear and side of the room.

We are indebted to William H. Baker, superintendent of the Atlas Co. for the foregoing data.

Kebec Boiler Circulator

A circulator for internally fired boilers has been designed with the aim of producing a simple, automatic device, requiring no special attachment to the boiler and which can be installed during the time required for cleaning or inspecting the boiler. It is the Kebec circulator, made by the Klein Boiler Circulator Co., 30 Church St., New York City.

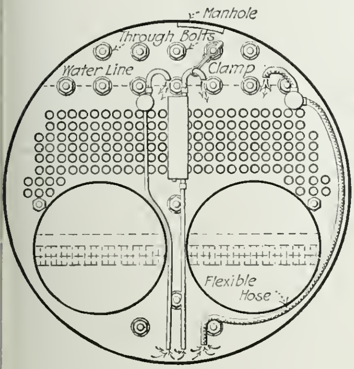


Fig. 1. Vertical Type of Circulator

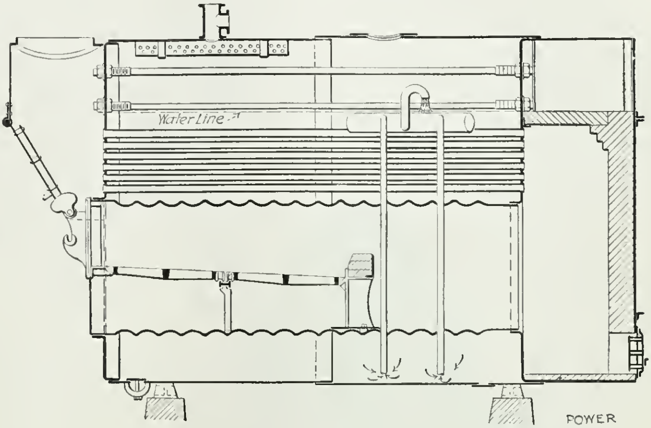


Fig. 2. Horizontal Type of Circulator

The circulator, of simple construction, can be placed in a boiler by inserting it through the manhole. It is necessary that the circulator body be covered with water at all times; the opening of the gooseneck must be several inches above the highest water level.

This device is of two general types. In the vertical type, Fig. 1, the body of the circulator hangs vertically between the groups of tubes and is fastened with a simple clamp on the through-bolt of the boiler; the inlet pipe comes near the boiler bottom and the discharge pipe above the water level.

The horizontal type, Fig. 2, is placed in boilers where the flues are so close together that a small space only is left between them. Hence the body of the circulator has to be placed horizontally above the flues with the suction pipes passing through the space between them, to the bottom of the boiler. The discharge pipe is above the water level. When the condition of the boiler is such that the suction pipes have to be bent, the circulator is equipped with flexible copper or bronze hose, Fig. 1, which can be formed according to the shape of the boiler or of the furnace.

The device is automatic in operation, is self-contained, and is operated by the physical law of vacuum and pressure created in part by the alternate heating and cooling of air, combined with the factor of differential water levels.

The circulator raises the cold water from the bottom, then warms and discharges it in the steam space, forcing the hot water to flow into the lower part of the boiler, thus maintaining an equal temperature throughout the unit.

The result of tests made to show the efficiency of the circulator is graphically explained by the diagrams, Fig. 3. The test was performed with a 200-hp. Continental Scotch-marine boiler. One thermometer was placed on the top, and another on the bottom. The first test was made without a circulator; the temperature on the bottom in 8½ hr. rose to about 329 deg. F. In the same boiler a circulator was installed and a second test showed that after the fire had been started at the same hour as previously, the water in the bottom was the same temperature as at the top in an hour's time.

The curve *a* shows the reading of the thermometer on top of the boiler; curves *b* and *c*, the reading of the thermometer on the bottom with and without the circulator. The difference between the curves *b* and *c* shows the advantage of the circulator in the boiler.

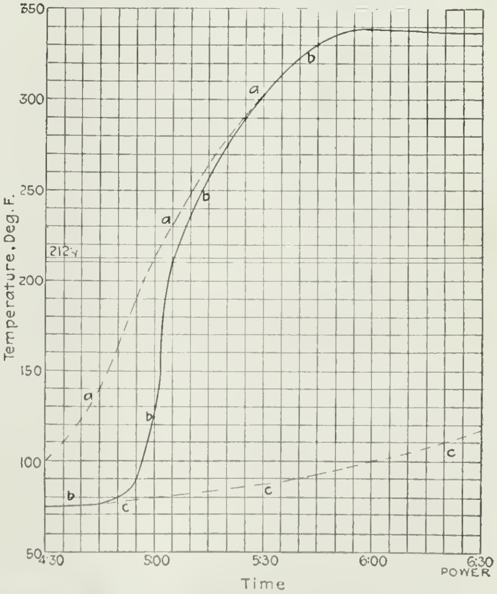
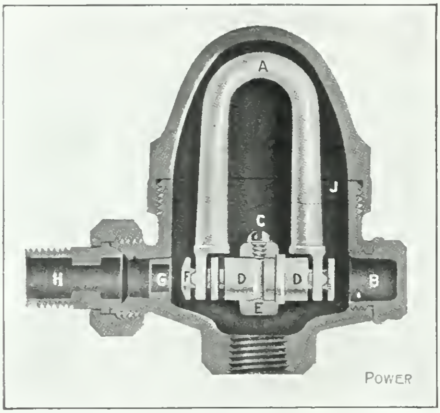


Fig. 3. Showing Temperature of Water in Boiler with and without the Circulator

Vento Automatic Valve

The Vento automatic valve, for vacuum or vapor heating, is a shell containing a copper-plated spring-tempered steel tube *A* filled with a volatile fluid hermetically sealed and so sensitive that a change in temperature of one degree is sufficient to operate the valve.

The cap nut *B* is for inserting the valve mechanism and to test the operation of the valve while it is in service. The cap screw *C* fastens the valve mechanism to the supporting bridge *E*; the sleeve D is the mounting for the valve mechanism and acts as a guide for the valve *F*, and also so supports the tube *A* that the movement of the tube must open and close the valve. The supporting bridge *E* is part of the valve body to which the sleeve *D* is secured. The bronze valve head *F* is moved back and forth by the tube *A*, the guide *D* holding the tube *A* in a central position.



Section through Automatic Valve

Before steam is turned on, the thermostatic tube is neutral and the valve is then wide open, and remains in that position until all of the air and condensation have been removed from the point to be drained. The instant steam arrives, however, the tube *A* expands, closing the valve tight. As condensation forms, the temperature lowers and the tube contracts, moving the valve from its seat and discharging the water. This valve is made by William S. Haines & Co., Twelfth and Buttonwood Streets, Philadelphia, Penn.

⁂

Regulation of Power Rates

By A. L. H. Street*

The following review of decisions announced by some of the highest courts of the country during the last few years serves to show that companies selling electric or other power to the public are as much subject to regulation of their rates by public authorities as are railroads, and upon the same general ground—that is, on the ground that they are quasi public corporations.

By asserting the right to condemn land for public use, it has been held that a power company estops itself to deny the power of the state to regulate its rates and service and to prevent discrimination. (Tennessee Supreme Court, Great Falls Power Co. vs. Webb, 133 *Southwestern Reporter,* 1105.)

In another case a hydro-electric power company has been declared by the Wisconsin Supreme Court to be a "public utility," and, as such, subject to state regulation of its rates and prohibition against discrimination in charges. (Village of Kilbourn City vs. Southern Wisconsin Power Co., 135 *Northwestern Reporter,* 499.) The court finds that a contract which runs counter to such regulations is invalid. The California Supreme Court has also declared that, on account of their quasi public nature, electric power companies are restricted to reasonable charges, which may be fixed by municipal ordinance. (Ex-parte Goodrich, 117 *Pacific Reporter,* 451.) Again, the North Carolina Supreme Court has decided that an electric company, by devoting its property to public service, becomes subject to regulations as to the maximum rates which it may charge. (Horner vs. Oxford Water & Electric Co., 69 *Southeastern Reporter,* 607.)

Power of Courts Defined

Although a court has jurisdiction to determine whether a rate complained of is reasonable, it has no power on reaching a negative conclusion to prescribe a reasonable rate. "In a case of this character, the court can review the action of the rate-making body only so far as to determine whether, under the rate presented and the other rates which the complainant may lawfully charge, it will be unable to realize a fair and just return on the value of its property devoted to the particular public use, and will amount to a taking of its property without just compensation." (United States District Court for the District of Oregon, Portland Railway, Light & Power Co. vs. City of Portland, 200 *Federal Reporter,* 890.)

Rates established by proper authority are presumptively reasonable. (Arkansas Supreme Court, Arkadelphia Electric Light Co. vs. City of Arkadelphia, 137 *Southwestern Reporter,* 1093.) Hence, when it appears that a city has been vested with power to fix rates, the burden is on a power company in suing to restrain enforcement of an ordinance prescribing rates to show that they are unreasonable or confiscatory. (Portland case cited above.)

Rates Considered as a Whole

A power company is not entitled to a reasonable profit upon each transaction, and a regulation of rates is valid, if a fair return will result from the rates as a whole, although a reasonable profit may not be derived from a small class of customers. (Missouri Supreme Court, State vs. Water, Light & Transit Co., 155 *Southwestern Reporter,* 826.)

Existing and unexpired contracts for power are impliedly subject to a reduction on lower rates being validly established by legislative authority. (Portland case.)

The courts have gone so far as to hold that although a public-service corporation is entitled to reasonable compensation for service rendered, it cannot legally suspend operations because of a reduction in rates. The remedy is a suit to enjoin enforcement of the law or ordinance prescribing such rates, if the same be unreasonable. (Florida Supreme Court, City of Gainesville vs. Gainesville Gas & Electric Power Co., 62 *Southern Reporter,* 919.)

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*Attorney and counselor-at-law, St. Paul, Minn.

LEGISLATIVE POWER IS DELEGABLE

The legislature may delegate its rate-fixing power to a public-service commission or other administrative body, to be exercised in conformity to standards established by the legislature. (New York Supreme Court, Appellate Division, Third Department; Village of Saratoga vs. Saratoga Gas, Electric Light & Power Co., 107 *New York Supplement,* 341.)

The constitution of Florida has been interpreted by the state supreme court as being broad enough to authorize the legislature to empower a municipality to fix reasonable gas and electric rates. (Gainesville Gas & Electric Power Co. vs. City of Gainesville, 58 *Southern Reporter,* 785.)

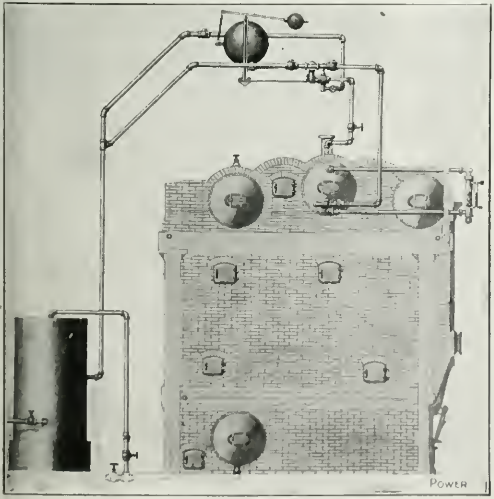
A city cannot fix rates unless clearly so empowered by its charter. (United States Circuit Court for the District of Minnesota, Minneapolis General Electric Co. vs. City of Minneapolis, 194 *Federal Reporter,* 215.)

A law authorizing a public-service commission to pass upon the reasonableness of rates charged by power companies supersedes previous charter provisions empowering cities to fix such rates. (United States District Court for the District of Oregon, California, Oregon Power Co. vs. City of Grant's Pass, 203 *Federal Reporter,* 173.)

⁂

Reiter Continuous Blowoff Boiler Cleaner

Depending upon the quality of the feed, impurities in greater or lesser quantities are deposited in a boiler in the form of mud, sludge and scale. To keep the boiler steaming properly, these impurities must be removed periodically. It has been customary to pump up one or two gages and to blow down once or twice a day, and sometimes oftener. This procedure tends to remove the impurities, but it allows them to remain in the boiler for some time and entails the loss of considerable water which has been previously heated.



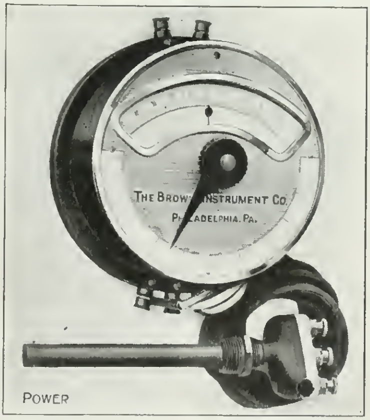
CONTINUOUS BLOWOFF CLEANER

To save this lost energy, the National Boiler Specialties Co., Elgin, Ill., is putting out the device shown in the illustration, which consists chiefly of a settling tank and a return trap. As may be seen, the tank is connected to the mud drum of a Stirling water-tube boiler. The blowoff is left open to carry the sludge over to the tank continuously and as soon as it is formed. It is then deposited in the bottom and the water, freed from its impurities, is returned to the boiler by the return trap shown at the top of the illustration. The piping is selfexplanatory; means have been provided to keep the trap from becoming air-bound. For this arrangement a practically clean boiler and the attending advantages are claimed, also the saving of the hot water otherwise blown to the sewer.

⁂

New Brown Resistance Thermometer

A new resistance thermometer has been brought out for measuring temperatures from 200 deg. below zero to 1800 deg. F. This instrument is adapted for low temperatures which cannot readily be measured with the thermo-electric pyrometer, and is particularly useful for indicating the temperatures in dryers and ovens, in machine bearings which may overheat, in motor windings and in transformers, on refrigerating machines and in rooms which must be maintained at a constant temperature.



RESISTANCE THERMOMETER

The instrument, manufactured by the Brown Instrument Co., Philadelphia, Penn., consists of a bulb or coil of resistance wire through which a current is passed, and which changes in resistance with a change in temperature. Bulbs at numerous points around the plant are connected by three-wire cable to the indicating instrument and switchboard, which can be placed at any desired point. In determining the temperature, it is simply necessary to switch any bulb on to the indicating instrument, as shown in the illustration. If a constant temperature is to be maintained, the pointer can be adjusted to this temperature and its deflection on the upper scale will show the increase or decrease. This instrument operates on either dry cells or storage batteries, or 110- or 220-volt direct-current lighting circuits.

Its chief advantages are the ability to read moderate temperatures from one central location without the necessity of going about from one point to another to read it as indicated on thermometers, and in the fact that the bulbs are of metal and not liable to be broken as is the case with a glass thermometer. The indications are guaranteed to be within 1 per cent.

⁂

Water-Hammer in Boiler-Feed Lines

By Albert H. Israel

In plants where the feed water is at a temperature of 212 deg. F. on the suction side of the pump, and where the head of water above the center of the pump cylinder is low, water-hammer generally occurs on each stroke of the pump. This trouble is experienced in many plants, but exactly what takes place in the pump cylinder is not generally understood.

On each suction stroke a partial vacuum must be produced in the water cylinder before the difference in pressure on the two sides of the suction valve disks becomes sufficient to open them. If the pressure on the suction side were high enough, the water would rush in immediately when the piston starts forward. The water being at the atmospheric boiling temperature, some of it immediately passes into vapor when the pressure in the cylinder becomes lower than the pressure of one atmosphere. But to take in water, this difference must be maintained, and thus at the end of the suction stroke there is considerable vapor present in the cylinder. On the discharge stroke, the piston, finding a cylinder partially filled with steam, rushes down upon this and stops suddenly when it strikes the solid body of water, which cannot be compressed, causing a loud knock due to the sudden impact. This is transmitted through the entire pressure side of the feed line, and not only causes excessive pressure for the instant, but also is productive of line leaks. There are various ways in which these may be prevented, some of which are:

(1) Lower the temperature of the water flowing to the pump. This would in most cases solve the problem immediately, but should never be resorted to, for, although effective, it would prove uneconomical.

(2) Raise the feed water heater or the utility tank. In any case the water should flow to the pump by gravity. Many think that because the level of the water in the heater is above the cylinder of the pump, this requirement has been satisfied, but this is not always so, because the whole, or at least a large part, of the head of water available, is required to overcome the friction of pipes and fittings.

(3) Avoid an excessive loss of head due to the friction in piping. Often the pipe is too small for the water required, so that an excessive loss of head due to friction results from high velocity. Unnecessary bends and other fittings should be left out of the line when not absolutely required. When valves are required, only gate valves should be used, for these give the minimum resistance to the flow.

(4) Lower the feed pump. This is a good method to stop the hammering when it is possible to adopt it. When the direct-acting feed pump is replaced by a moderate-speed triplex belt- or a motor-driven feed pump, in addition to the lowering, then the desired result is doubly assured.

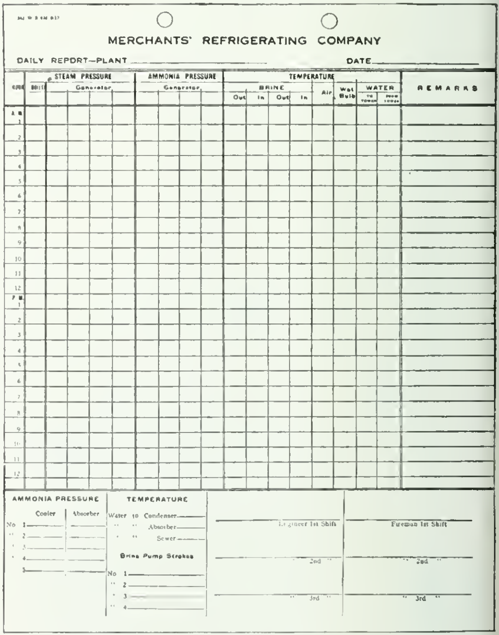
(5) Do not use springs on the suction valves of the pump which are too heavy. If too great, a difference in pressure on the two sides of the disks is required to open them; the greater part of the available head may be lost in overcoming their resistance to opening.

The particular method which may be employed to best advantage in any case will depend upon the conditions. Sometimes a combination of several ways becomes advisable, depending on the location of the plant in the building, headroom, etc.; the layout of the piping and the money available for the purpose.

⁂

Absorption-Plant Report Sheet

The form shown is used for the daily-report sheet in a large absorption plant. Several other forms were drawn up, but this one proved best suited to the needs. The sheet is 8⅜ in. wide by 10¾ in. long and is perforated at the top to allow inserting in a loose-leaf folder. An atmospheric cooling tower is used, which accounts for the columns "Air" and "Wet Bulb." The "Remarks" column would be better if made wider.



MERCHANTS' REFRIGERATING COMPANY

DAILY REPORT—PLANT ____ DATE ____

		STEAM PRESSURE				AMMONIA PRESSURE				TEMPERATURE								REMARKS
		Generator				Generator				BRINE				Air	Wet Bulb	WATER		
										Out	In	Out	In			[illegible]	[illegible]	
A. M. 1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
P. M. 1																		
2																		
3																		
4																		
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9																		
10																		
11																		
12																		

AMMONIA PRESSURE

	Cooler	Absorber
No 1		
" 2		
" 3		
" 4		
5		

TEMPERATURE

Water to Condenser ____
" " Absorber ____
" " Sewer ____

Brine Pump Strokes

No 1 ____
" 2 ____
" 3 ____
" 4 ____

Engineer 1st Shift ____ Fireman 1st Shift ____
" 2nd " ____ " 2nd " ____
" 3rd " ____ " 3rd " ____

Log Sheet for Absorption Plant

We should be pleased to receive good daily-report and summary sheets from a compression plant. The sheets should be thorough and yet not burdened with useless items.

⁂

Flotation—A body lighter than water will not rise unless the water can get under it. Thus, if one side of a block of light wood perfectly flat and smooth and varnished to exclude moisture be placed on a similarly prepared surface on the bottom of a vessel and held there until the vessel is filled with water, it will then remain at the bottom due to the unbalanced downward pressure of the water.

Editorials

An Unconstitutional License Law

Laws providing for the examination and licensing of engineers are passed to insure the public against danger from the careless or unskillful handling of power-producing apparatus—not to make a corner in engineers.

Buffalo has an ordinance which prohibits any owner of a steam plant from permitting other than a licensed engineer to run it, or other than a licensed engineer from running such a plant, but denies a license to any but a citizen of Buffalo.

In 1912 came one F. R. Williams, of Syracuse, to Buffalo looking for a job. He applied for a license and was refused on account of the above ordinance, whereupon he brought a charge of conspiracy against the National Association of Stationary Engineers and the International Union of Stationary Engineers, and pleaded his own case in court. The bill against the organizations was dismissed, but Judge Hazel, in the United States Circuit Court, handed down the opinion that the provisions of the charter and ordinances with regard to the granting of licenses are unjust, discriminatory and void in that they impair the complainant's right by preventing him from following his trade in Buffalo.

The examining authorities in New York City will get a similar jolt just as soon as anybody has the nerve to contest one of their refusals under their similarly restrictive law.

*

Emergency Stops

We fought the Revolution for our own freedom, the Civil War for the black man's freedom. Freedom from tyranny of all kinds was, is and ought to be the guiding principle of all our laws, and there are still more laws needed when conditions can exist to permit the following, a story from real life and probably true, except in details, of many engineers:

This man is in charge of a 1500-kilowatt steam turbine, the emergency stop on which is completely out of commission. When he asked that it be put in order by the manufacturers' experts, his superiors not only paid no heed, but showed their displeasure in a way that warned him to hold his tongue if he did not want to lose his job. Having a family of small children, he cannot afford to be out of work, so he has to put up with things as they are.

Twice within the last few months the turbine has lost its vacuum from low water in the pond. Fortunately the engineer was near enough to pull the chain that trips the weight and shuts the steam off. The turbine is usually slightly overloaded, and when the vacuum is lost the turbine slows down. Had the engineer not been around at the time, the speed would have fallen until the turbine dropped its motor exciter, which would have meant dropping the whole load. Then, rid of its burden, it would have speeded up until it probably would have burst with disastrous results. This man is all alone and has to supervise the engine room and the men in the fire room. When he goes on his tours downstairs, his mind is perpetually and anxiously on the turbine.

Worry like this is life-shortening, even if it does not drive him to suicide, and if the turbine explodes he is likely to be killed. Then the bereaved family will be even worse off than if he lost his place. No matter how it is viewed, this engineer is up against a losing game.

In the name of consistency, wherever there are laws or ordinances compelling the provision of safety valves on boilers and safety devices on elevators and periodic inspection of both, and this should be wherever human life and property are jeopardized by them, there should also be compulsory provision of emergency stops on turbines and engines and their frequent inspection. Just so long as an employer's selfishness or indifference can make it necessary for a man to work in such mental torment as has been outlined, we are far from being a free country. By contrast the life of a galley slave in the days of ancient Rome was a sinecure.

*

Perfecting Laws

The engineers in most states would be so glad to get any boiler-inspection laws at all, that they are not prone to be too particular. Poor laws, however, may be worse than no laws and it is sometimes harder to get amendments than the original laws, so that all those working for legislation in their states will do well to strive to get the best laws passed in the first place. To this end the experience of other states already having laws of the kind can be studied to advantage.

Ohio was one of the states that did not have this privilege to any great extent, Massachusetts being the only state that had adequate boiler-inspection laws ahead of it. Good use, however, was made of the Massachusett's experience, and the laws, as first adopted, were very commendable. Then, to make doubly sure of a good job, the boiler inspectors licensed by the state to inspect under the provisions of the Ohio State Boiler Inspection Law, of which there are now about one hundred, organized the Ohio State Boiler Inspector's Association to intensify their influence in perfecting the law. In the words of its treasurer, F. P. Somers, "Any new law of this description is bound to have some rough spots in starting out, and we recognized that as individuals we could do nothing to smooth out these rough spots, but as an association we could and have done a vast amount of good."

Socially and for business the association occasionally meets with the Ohio State Board of Boiler Rules and the chief state inspectors. The rules laid down by the board are discussed and some have been changed, some abolished and some new ones made in consequence. In this way a friendly spirit of coöperation has been estab lished between the members of the board and the inspectors that has been of great advantage.

Ohio now has a first-class boiler law, well administered by high-grade men without any friction, and the boiler owners and the public at large have reaped the benefit.

The three ideas, then, that we wish to leave with all who are working for boiler laws in the states still without them are these:

Get a boiler law:

Get the best law possible at the start;

Organize, if necessary, to perfect the law as soon as experience in its operation develops its defects.

Business Grease

Woven in with a valuable article on oils and lubrication, page 169, is a homily on business relations between buyer and seller that applies just as much to other lines as to oils and greases. The article is by L. D. Allen, and from among its nuggets of good sense we have selected the following as especially deserving the emphasis of repetition on this page:

> A little friendly attention often inspires a solicitor to offer a prospective customer values that he knows should retain that friendship, and at a cost sufficiently low to minimize competitive assaults.
>
> Sentiment, when it is mutual, invariably profits both the buyer and the seller.
>
> What is needed is not so much better products as better relations and understanding between the producers and the consumers themselves.
>
> Any deal that is not profitable to one is not profitable to the other.
>
> The bargain that yields mutual satisfaction is the only one likely to be permanent.
>
> The losing customer is the lost customer.
>
> The keynote of modern commerce is service.

Salesmen have a way of saying they have "sold" such and such a customer, which unfortunately is sometimes literally true. What they mean, however, is that they have made a sale to that customer. Carrying out the above admonitions the customer will not be "sold" in the sense of being deceived. Mr. Allen can well be considered an anti-friction specialist in more ways than one. With the above suggested lubrication in the dealings between the buyer and seller they should work smoothly together.

Use Allen's Business Grease.

Making Up Lost Education

Men are often heard deploring their lack of education who might just as well educate themselves, no matter what their ages. There are some things that a man loses the ability to learn as he grows older. A boy fourteen can do certain tasks in a cotton mill better than he will ever be able to do them again. This does not apply to mental processes. Some of the best minds have matured late, but they have ripened thoroughly and deeply. In these days of cheap paper, cheap printer's ink and the linotype, there is a wealth of educational material at every man's elbow.

The most common feeling among men who did not make the most of their schooling, or who were obliged to quit school young, is one of despair of ever being able to read intelligently. They got the idea in the little time while they were in school that education is a thing which requires hard study and persistent oversight. That is wrong. The best education there is comes almost unconsciously. The painful part is the getting familiar with the tools of education—reading, writing and arithmetic, and a little more of the same sort of stuff—at an age where it is natural for a child to prefer going fishing, and when he cannot realize the value of these tools.

The two hardest tasks that the writer can remember were to spell "chisel" and to learn the multiplication table up to 12 times 12, which he never uses above 10 now. He wanted a chisel and his father promised him one when he could spell the word. He got the chisel, but he earned it. In school there was no reward; there was punishment and the hatred that went with it.

When men are older and begin to wish they had stuck it out and got an education, they are apt to think that the only way to get it is to start where they left off, and go on as if they were children again. On the contrary, that is the child's way of being educated and not the man's way. They pick up books on some subject that they feel they ought to know about and they find that they are entirely unable to understand them. They despair of beginning over and they cannot read what they find that applies directly to what they want to know. The trouble is that most books are written by men who learned what they know from the standpoint of the so called educated man. The cart is before the horse when the man who got his education by hard knocks looks at it. For him about all there is printed that is right end to are the trade papers, the catalogs of manufacturers and the standard handbooks.

Suppose you want to know how high to set a water tank to get a pressure of thirty pounds per square inch. You find in a handbook a rule which will give you the answer, but it will not tell you why the rule is right. You try to apply the rule to oil or gasoline and it will not work, because it is not water. A textbook will tell you all about it, but it is under the title, "hydrostatic head," which may not mean a thing to you, and the less it means the more likely it is that you need to know. The other thing you can do is to look in the back numbers of the papers until you find something of the kind, or else write to the editor and ask him to publish something about it. The textbook writer cannot be expected to do this because his profit lies in writing the kind of book that will sell best—the kind that college students can read and will be impressed with because of its apparent difficulty.

The main problem in self-education is to find the right reading matter. Get it as simple as necessary for a beginning and the more difficult reading will later become easy.

* * *

Boston is paying $103 per year per arc light. Let's see. Was not Massachusetts one of the first states to adopt a Public Service Commission?

* * *

Maximum efficiencies to the engineer are like the fixed stars to the mariner; though neither can be touched, they are invaluable as guides to the right way.

* * *

Now is the time to begin arranging the educational program for the coming season. Organizations which wait until October will find themselves handicapped.

* * *

The elevator operator who makes a habit of depending on the automatic to stop the car at the top of its travel is another of those didn't-know-it-was-loaded fellows.

Correspondence

Allowance for Expansion

Under the above heading, on page 25, July 7, W. Burns says some things entirely new to me. I have had no experience with connecting rod-end bearings (or other bearings) that would expand away from the pin, and I have never seen a crankpin gripped enough to slow down the engine. I have seen them smoke and flash fire, but the engine did not slow down until the throttle was closed.

My rule is to make all adjustments when the parts are expanded, the first thing after shutting down after the day's run. I do not think the type of rod end has much to do with the safe adjustment of the boxes.

L. JOHNSON.

Exeter, N. H.

⁂

Boiler Explosion in Hawaii

I have been much interested in POWER's accounts of boiler explosions. Here are illustrations showing an exploded boiler in Hawaii.

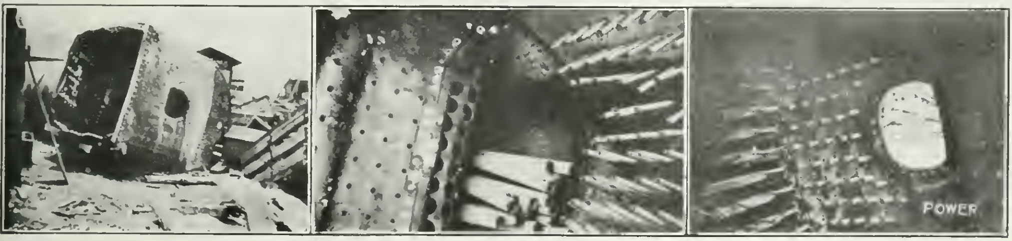


Fig. 1 Fig. 2 Fig. 3

CONDITION OF THE BOILER AFTER THE EXPLOSION

The explosion occurred one Saturday afternoon about 4:20 p.m. and was the result of low water. The native Hawaiian fireman was killed and his body blown into the street about 60 ft. A passerby was badly hurt by flying timbers, etc.

The locomotive type boiler was one of a pair used to operate a coal hoist and conveyor. Fig. 1 shows where it fell after flying about 150 ft. through the air and describing one complete somersault before it stopped. At the lower part of Fig. 1 the edge of the torn crown-sheet may be seen.

Fig. 2 shows the interior of the firebox, with the crown and tube sheets pulled off from the stay-bolts and tubes and folded back upon the front of the firebox. The white spots are small patches of scale. Fig. 3 is another interior view of the firebox looking toward the door, showing the stay rods and the stay-bolts supporting both the crown-sheet and the front of the firebox. At the left side of the firebox door and at the lower side the plate tore like a sheet of paper.

I believe the crown-sheet gave way first above the firedoor. Few of the stay-bolts were broken, and these were broken probably when the boiler struck the ground and rebounded. All the stay-bolts show that they had been very hot, and some of the heads had small blisters.

No. 2 boiler was tilted over on its side and it is a wonder that it did not explode. Steam poured from every broken connection and there was some noise! Here in Hawaii there is no law that requires boilers to be inspected and no license law for engineers or firemen.

CHESTER E. BLACOW.

Paauilo, Hawaii, T. H.

⁂

Preheating Furnace Air

On page 24 of the July 7 issue, Mr. Olmstead describes the means to preheat the air for combustion. In our plant the air is preheated, but in a different manner. The ceiling of the boiler room is low and the air is drawn over the tops of the boilers to the forced-draft fan, which is housed in and connected to this area only.

This air is usually about 150 deg., which saves considerable coal and helps ventilate the boiler room. This system has given good results for several years.

Although there may be some reasons for not doing so, it seems to me that the condensation referred to should go back into the boilers, where it would do more good than heating the air for combustion. If it contains oil it can be purified. The amount of saving by putting the hot water directly into the boiler would be 12 to 14 per cent. if the makeup water is cold.

Another waste of heat is in the flue gas. In many of the larger plants economizers are installed, which use part of it, but in the average small or medium-sized plant no attempt is made to save any of this heat, which is usually at from 450 to 600 deg.

Some time ago the air for heating a certain building was blown by a fan through a heater in the breeching of the boiler and heated by the waste gases. This system in some instances might have its good points, although it would require frequent cleaning and would decrease the draft to some extent. This same idea might be used to advantage in heating the air for combustion provided there was forced draft. I know of one instance in which the hot air from over the tops of the boilers was used by means of a fan to heat the adjacent workrooms, but on account of the amount of gas in it, and also the soot, it was discarded for direct radiation.

J. C. Hawkins.

Hyattsville, Md.

While the device used for preheating is ingenious, yet a closer analysis would seem to indicate that he must look to something else than his preheater for this saving.

Let us assume that the preheater is capable of raising the temperature of the air supplied to the furnace to the same temperature as the water, namely, about 200 deg. F. from an initial temperature, of say, 60 deg. F. Since the specific heat of air at constant pressure is 0.2375, this preheating of 140 deg. would amount to a heat absorption per pound of dry air of

$$140 \times 0.2375 = 33.25\ \textit{B.t.u.}$$

Since one pound of coal burned under usual conditions requires about 22 lb. of air (allowing for a reasonable excess), the preheating per pound of coal burned would be about

$$33.25 \times 22 = 731.5\ \textit{B.t.u.}$$

no allowance being made for the heat picked up by the small amount of water vapor present in the air. Assuming that the coal is completely burned and has a heat value of 14,500 B.t.u. per pound, the amount of heat supplied to the furnace per pound of coal burned would be only about

$$731.5 \div 14{,}500 = 0.0504 \text{ or } 5.04\ \textit{per cent.}$$

of the heat of the fuel burned.

He gives no data by which the steam consumption of the pump which circulates the water can be computed, but since most small pumps are notorious for their steam consumption, it seems probable that when this item is considered, any apparent advantage to be obtained from preheating the air in this manner will vanish.

William A. Dunkley

Atlantic City, N. J.

Compressor Air Supply Stopped

This seemingly bad case turned out to be due to a very simple and natural cause. A Crowell rotary belt-driven air compressor, giving about 150 to 200 cu.ft. of air per minute, at 15 lb., had done good service for over a year, when suddenly it began to fall off, both in its quantity and pressure of air. The chief mechanic did all that seemed possible to repair it, cleaning the relief valve, etc., but in vain; it would not compress.

Finally, the brilliant idea occurred to us that since there was an outlet for the air there ought to be an inlet. The inlet was covered with fine wire gauze, about 70-mesh, to keep out anything that might be detrimental to the compressor. (This happened at a woolen mill, where the air may be more or less filled with all sorts of flocks and lint.) We found the gauze completely covered with a peculiar mixture of fine lint, dust and grease, which acted practically as though the screen were varnished. When the screen was cleaned the air compressor did its work as intended.

C. S. Palmer.

Newtonville, Mass.

Operation of the Venturi Meter

It was stated in the March 24 issue that, in a properly constructed venturi tube, the two cones of the meter might be separated at the narrow part, and yet the swiftly moving water at this point would jump the gap without escaping.

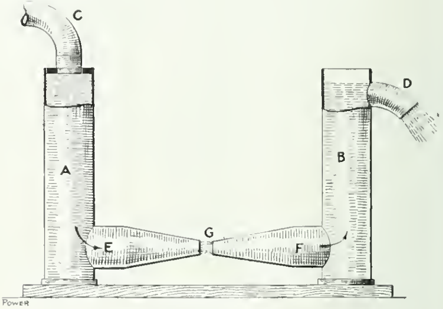


Fig. 1. Glass Model Illustrating Flow in Venturi Meter

Fig. 1 illustrates a glass model which demonstrates this peculiar action. Water is supplied continuously to the cylinder *A* by the pipe *C* and at such a rate that the level is maintained in the former at the top. As the water approaches the small end of the cone *E* its speed is greatly multiplied. The liquid then jumps the short open space *G* without leakage, begins to lose some of its velocity as it travels along the cone *F*, and finally rises nearly to the top of the cylinder *B* to be discharged through the outlet pipe *D*. In other words, from a point of no pressure (atmospheric pressure) at *G*, the water has actually flowed "up hill" against a considerable head. What has really happened is that the head or pressure in *A* has been temporarily translated into velocity at *G*, and then back again into the head in *B*. Upon trying the experiment it will be noticed, however, that the water level in *B* does not stand quite as high as in *A*, due to the slight friction loss.

The interior contour of a standard venturi meter tube is shown by Fig. 2. The shorter or inlet cone extends from *A* to *B*, the flow taking place in the direction indicated by the arrow, the outlet cone is about four times as long as the inlet cone and the entire outline corresponds closely to the form taken by the flowing water in passing through the meter tube at rates ordinarily met in practice. Those unacquainted with the principle of the meter often refuse to believe that practically as much water can be put through a venturi tube as through an equal length of straight pipe of the same diameter as the tube inlet and under the same pressure. They argue

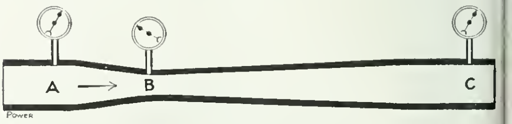


Fig. 2. Contour of a Standard Venturi Meter Tube

that if such were the case, they would make all of a pipe line the same diameter as the contracted part, or throat, of the meter tube, losing sight of the fact that the throat is very short and that pipe friction depends upon length as well as upon diameter.

Engineers "from Missouri" have to be shown by checking the readings of a pressure gage in the pipe line preceding the meter tube, before and after the meter is installed, with all conditions of operation identical. If pressure gages are inserted at *A*, *B* and *C*, Fig. 2, their hands will stand at relative positions, as illustrated, showing a decided drop in pressure at the throat but apparently a full regain at the outlet end. Actually, in commercial meters, there is a loss in pressure between *A* and *C* of one-quarter pound for normal rates and one pound for maximum rates within the measuring range of the meter.

The throat *B* is made from one-third to one-half the diameter at *A*, and the difference in pressure at *A* and *B* varies from $\frac{1}{16}$ to 10 pounds. This difference always bears a definite relation to the velocity of the liquid through the throat. The throat velocity and the throat area being known, the volume in gallons or cubic feet is easily computed. In actual practice, ordinary pressure gages are never employed because they are not sufficiently sensitive to small variations in pressure. Their use also involves the taking of frequent readings and tiresome calculations to determine the actual pounds, gallons or cubic feet discharged in a given period. Various forms of indicating, recording and registering instruments are on the market which are adaptable for giving direct readings in any units desired.

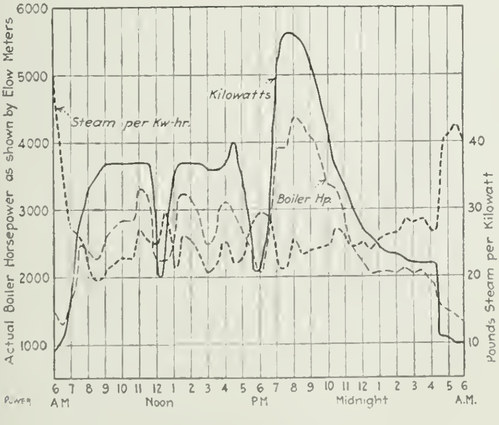
Charles G. Richardson.

Providence, R. I.

*

Utility of Flow Meters

The indicating steam-flow meter is one of the most useful additions to the boiler room in recent years; with a large number of boilers and all kinds of firemen, it has become almost indispensable. The engineer can detect a boiler that is not steaming properly, whether it is the fault of the fireman, the coal or the boiler, or perhaps all three together. At regular intervals, readings of the meters on all boilers should be taken, including the ones banked. The flow meter has shown that banked boilers will produce considerable steam just after renewing the banks, a fact not generally known before.



Readings Plotted

By using these readings a curve can be plotted showing the required boiler horsepower at any interval. In a central station the use of simultaneous wattmeter readings will determine the required boiler horsepower per kilowatt-hour or the pounds of steam per kilowatt-hour.

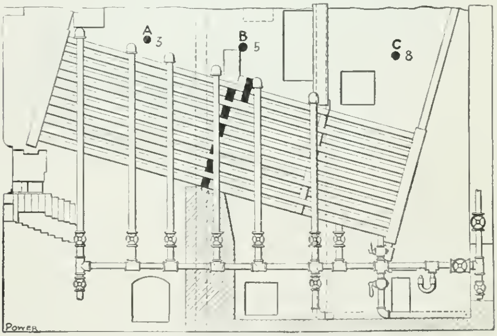
John F. Hurst.

Louisville, Ky.

*

Soot Blower Pipe Corrosion

On some of our boilers the piping of the soot-blowing system lasted only a few months before it wasted away internally. At first the trouble was thought to be due to water of condensation standing in the lines, but a thorough system of drains was installed which proved the fallacy of this idea. It was found that the operator had been leaving the individual valves open on the branch lines. The result was that the difference in the draft between the front and rear of the boiler caused a circulation of gases through the soot-blowing pipe outside the setting, which, mixing with the moisture present, formed a highly corrosive acid. By keeping all the branch-line valves closed when the blower was not in use the corrosion stopped.



Draft at Different Points

The illustration shows the amount of draft at points *A*, *B* and *C*, which will explain how a circulation of gas through the pipe was possible. This was the only trouble of this kind in our plant for years.

John F. Hurst.

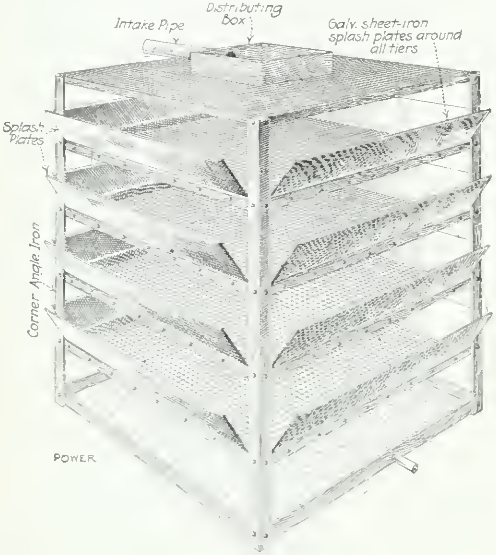
Louisville, Ky.

*

New Cooling-Tower Design

Visiting a new power plant recently, I saw what was apparently a light and efficient cooling tower. It was situated on the roof of the plant and was arranged as in the illustration.

The frame was of angle-iron corner posts, with horizontal ties of 2x4-in. cypress, bolted to the corner angles at intervals of about three feet. To these ties were fastened one-quarter-inch mesh galvanized wire gravel screens, stretched across the tower to distribute the water. The distributing box at the top was also of galvanized sheet iron and wire screen. Instead of the usual wooden siding or splash boards, galvanized sheet-iron plates were used supported by brackets. The parts are easily repaired or replaced and the cost of maintenance is small.



Cooling Tower

Water is broken up into a fine mist after spreading itself over the screens before falling to the next lower one. The tower has proved remarkably efficient in the hottest weather compared with other towers not using forced draft.

B. W. Dennis.

Columbus, Ohio.

⁂

Thrust Bearings

Turbines with vertical shafts or other heavy machines running on such shafts, exert a great pressure on the step bearing, and it is difficult to keep it cool for two reasons. The lubricant is squeezed out of the bearing and there is a tendency, due to centrifugal force, for it to be worked out to the periphery, where it runs off; and there is no good way to get it back to the center. There are many cases where the position of the bearing renders lubrication specially difficult.

In these instances it is well to employ anti-friction bearings, with conical rollers. These must be arranged exactly radially, with all their axes in a plane exactly at right angles to that of the shaft; and so that they may not touch each other. These three points being taken care of, there will be a great reduction in the friction, assuming that the rollers are of the same diameter and taper and of good, uniformly hard metal.

In one test the weight on the bearing was 8000 pounds; the bearing had an area of 76.58 sq.in., making 104.5 pounds per sq.in.; the power required to rotate the shaft by a pull on a radius of 10½ in. with a plain bearing was 400 pounds. With a conical roller bearing, the area and load being the same, 20 pounds only was required to rotate the shaft. In the first case, the coefficient of friction was 0.05; in the second, only 0.0025.

In freezing weather, when oil will not flow down to the footstep of a water turbine, about the only way to keep the step in good condition is to use roller bearings.

Robert Grimshaw.

Dresden, Germany.

⁂

Handy Soft Hammer

Every engineer realizes that a copper hammer or one of some other soft metal is almost a necessity around the power plant, although it is sometimes impossible to get the company to see it. An engineer can usually have a cheap, serviceable hammer by melting some old babbitt or lead pipe usually to be found around the plant and pouring it into a suitable mold.

The mold may be made as follows: Clamp together flatwise two pieces of 2x4-in. hard wood about 6 in. long. Bore a hole 2½ in. in diameter by 4 in. deep (half of the circle in each block); then at the center gouge out a socket to hold the eye core. Make the core out of a piece of hammer handle, slightly tapered, so that it may be easily driven out. With the core in place, clamp the mold in the vise and pour in the metal. When cold, the mold may be taken apart and the eye core knocked out.

This hammer will stand a lot of hard usage, and when broken it may be recast. Molds for different sizes can be made as wanted, and if taken care of they will last or years.

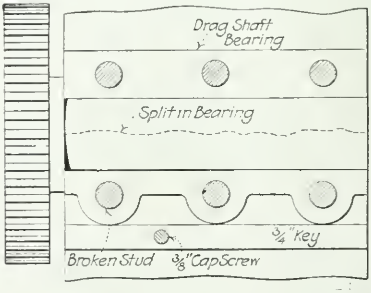
If a crucible is at hand, use brass or copper instead of lead or babbitt. The wood mold cannot be used because the temperature is too high. A mold made of a split pipe, however, will do very well for a brass hammer.

J. C. Hawkins.

Hyattsville, Md.

⁂

Repair to Bearing



Key Inserted to Hold Broken Bearing in Place

The breaking of a tooth in the drive pinion on the main shaft of a large gas engine caused the drag shaft to be forced back, shearing two studs and splitting its bearing the entire length. As there was not time to wait for a new bearing from the factory, the broken one was taken out, the side squared up and the slot in the bed, where it had been trued up for the bearing, was filed square. The bearing was then replaced and a ¾-in. key driven in the space between it and the end of the slot, forcing the two halves of the bearing securely together. This key was then secured by a ⅜-in. capscrew. The entire operation did not take more than three hours from the time of breaking the tooth until the engine was running again.

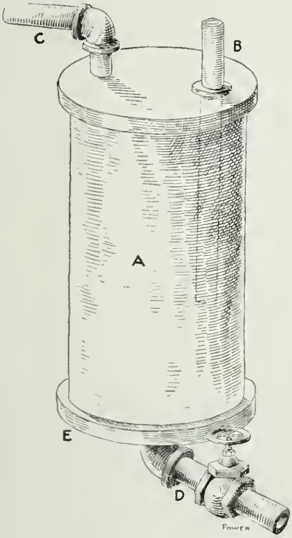
William Vaughan.

Salem, Ohio.

⁂

Gravity Boiler Skimmer

A home-made automatic gravity skimmer for boilers is shown here. It works well, taking out about half a gallon of thick, muddy mixture every hour, when river water is used.



Gravity Boiler Skimmer

The body *A* is wrought-iron pipe (about 8 in. is a good size), capped or flanged at each end. Pipe *B* is connected to the surface blowoff; *C* is connected to the bottom blowoff pipe between the valve and the boiler. This construction is different from any I have seen. (The pipes *B* and *C* are taken from the top of the boiler, with one extended down inside to the water level and the other below it). The pipe *D* is the blowoff from the mud collector. The bottom *E* should be as low or lower than the boiler bottom but it may be at any convenient point.

The skimmer will prove satisfactory only when a fairly constant water level is maintained, in which case it will do as good work as any.

James E. Noble.

Toronto, Ont.

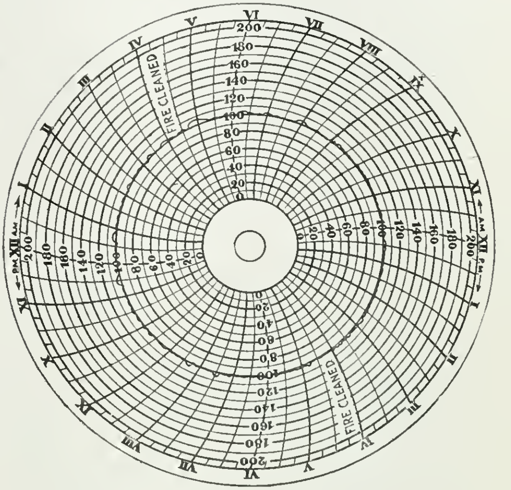
⁂

Steam Chart with Hand Firing

In the Mar. 31 issue, under the foregoing title, A. E. Anderson shows a good steam chart, but I want to show one made by my men under different conditions.

Instead of a battery of boilers, as Mr. Anderson has, which certainly steadies the load and gives a better chart, we have one 175-hp. return-tubular boiler in service at a time. When our load is lighting, for instance, and the 40-hp. motors for the elevator service are cutting in and out, or frequent changes of 80 hp. in the load occur, we will be carrying over 200 hp. besides using steam for other purposes, such as pumps, turkish bath, etc. This means that the boiler is doing nearer 225 hp.

We clean the fire at 1 p.m. and again at 4 a.m. The feed water ranges near 210 deg. all of the time. We burn bituminous coal, weighing it out to the day and the night man, weigh the ash made by each, meter the evaporation, the kilowatt output, etc. The evaporation averages 9 lb. of water per pound of fuel with an ash percentage of between 8 and 10.



Steam Chart, Showing Steam Pressure Carried with Hand Firing

The boiler is hand fired and the firemen are careful.

Asa P. Hyde.

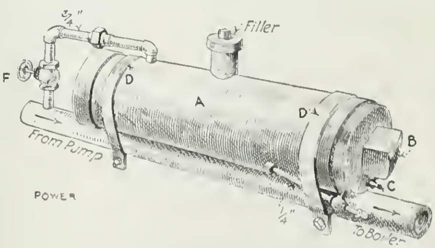
Binghamton, N. Y.

⁂

Home-Made Graphite Boiler Feeder

The illustration shows a simply and easily constructed graphite feeder that I built some time ago, and which proved satisfactory in every way.

To make it, take a piece of 6-in. cast-iron pipe *A*, 24 in. long, threaded and plugged at the ends, as at *B*. In one plug insert a petcock *C*, which serves as a drain and also shows when to refill with graphite.



Home-Made Graphite Feeder

The pipe *A* is secured to the boiler feed-water line by two straps *D*. At the top of the tank *A* there is an opening for filling. The water in injected through the ¾-in. pipe and valve *F*, the latter regulating the flow, the graphite being forced into the feed-water line through the 1-in. pipe, which has a valve to control the amount fed.

J. A. Lucas.

Ozone Park, L. I., N. Y.

Water Rheostats for 2200 Volts

In the issue of June 17, 1913, R. L. Daugherty described a water rheostat for 2200-volt, three-phase current, which, while undoubtedly satisfactory for that particular test, left the impression that a water rheostat can be used on 2200-volt power-plant testing provided a creek is available. As a matter of fact, a small stream of water under a few pounds pressure from an ordinary garden hose will supply all the water necessary for 200 kw. or more.

The drawing, Fig. 1, shows a 2200-volt, single-phase or three-phase water rheostat constructed from material which is always available around a power plant.

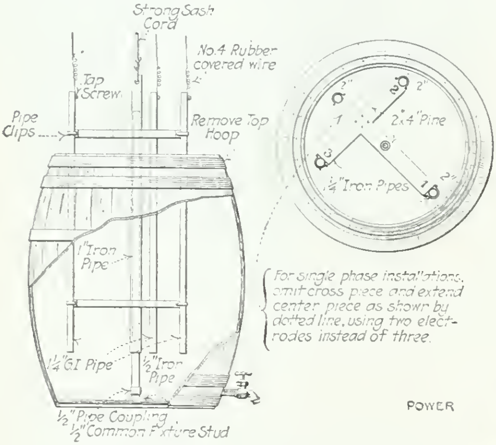


Fig. 1. Showing Construction of Rheostat

Two frames are constructed in the form of a T, to which 1¼-in. pipes are secured at the three ends, as shown. This triangle of pipes forms the electrodes, to which wires of any convenient size are attached by soldering or by means of screws. A 1-in. pipe is placed in the center of the triangle as a support and guide for the electrodes, and a ½-in. pipe is secured in the center of the bottom of any large barrel. This latter pipe fits inside of the first, so as to prevent the electrodes from swinging to the edges of the barrel. It is well to remove the top hoop, as it prevents the possibility of charring the ends of the staves. A hose bibb can be inserted near the bottom of the barrel for attaching a ¾-in. hose, or the hose can be dropped into the top of the barrel. The rheostat can be supported on blocks of wood or rest directly on the ground. Water can be allowed to overflow the top edges of the barrel or may be carried away through a pipe attached near the top.

When the barrel is filled with water the electrodes can be easily adjusted to a level position so as to equalize the load on each phase. Any desired load within the capacity of the rheostat can be obtained by adjusting the depth of emersion. The capacity of such a rheostat depends on the quality and quantity of water available for cooling purposes. The chart in Fig. 2 shows a few capacity-emersion curves for different qualities and pressures of water. The form of the load curve depends upon the quantity, hence the pressure of cooling water and the angle or slope of the curve depends on the quality of the cooling water. The lower curve is the result of using slightly brackish cooling water.

The writer has used this type of rheostat extensively on 2200 volts in various sections of the country. A rheostat constructed with a 56-gal. oil barrel and electrodes in a triangle 13 in. on centers will have a capacity of from 50 to 400 kw. Mere contact of the electrodes with the water will produce a load of from 3 to 15 kw. The capacity can be increased by reducing the size of the triangle or increasing the size of the electrodes, but in no case should the electrodes be less than eight inches on centers. With a steady flow of cooling water constant load can be maintained.

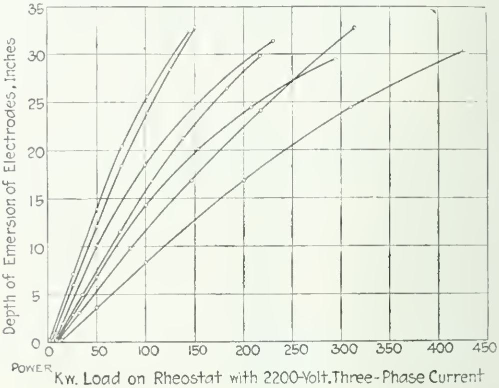


Fig. 2. Capacity-Emersion Curves

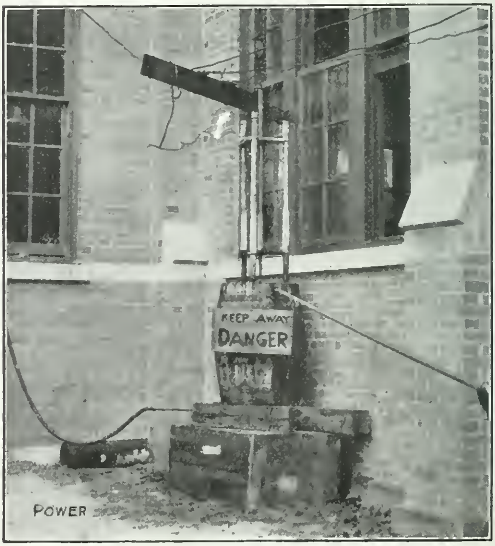


Fig. 3. Rheostat in Service

P. M. Anderson.

Washington, D. C.

Inquiries of General Interest

Fluctuation of Governor—Can a centrifugal governor maintain uniform speed for different loads carried by the engine?

C. R.

Only approximately, as each load requires a different position of the throttle or cutoff valve, and the different positions required of the governor balls are only attained by different speeds of the engine.

Advantage of Dutch-Oven Furnace—What is the advantage of the Dutch-oven furnace?

W. J.

The principal advantage is in having a large combustion chamber and longer path for the hot gases before reaching the comparatively cool surfaces of the boiler, thus permitting of combustion at a higher temperature.

Outside Packed Pump—What is meant by an outside packed pump?

J. P.

One having a plunger piston which is packed from the outside of the cylinder by means of a gland and stuffing box, as distinguished from an ordinary piston pump in which the piston packing is inside of the pump cylinder.

Differential Plunger Pump—What are the advantages of a differential plunger pump?

R. T.

With a simple plunger or bucket pump, the discharge is intermittent, whereas with a differential plunger pump on the up-stroke twice the amount of water discharged is drawn into the lower chamber, and on the down stroke one-half of that drawn into the lower chamber is discharged. The continuous discharge permits use of a smaller discharge pipe, is less productive of shocks and prevents the accumulation of sand or sediment on the discharge valves.

Current for Three-Phase Motor—What current would be required in each phase for 10-hp., three-phase, 500-volt motor?

C. B.

A motor of the size stated would have an efficiency of about 88 per cent., so that the required input would be

$$10 \div 0.88 = 11.36 \text{ hp. or } 8474 \text{ watts.}$$

Assuming the power factor at 85 per cent., then using the formula for the power in a three-phase circuit, viz:

$$\text{Watts} = \text{amperes} \times \text{volts} \times \sqrt{3} \times \text{power factor}$$

and substituting

$$8474 = \text{amperes} \times 500 \times \sqrt{3} \times 0.85$$

or amperes = 11.5.

Vertical vs. Horizontal Water Turbines—What are the relative advantages of vertical-shaft and horizontal-shaft water turbines?

M. G.

There is practically no difference in efficiencies. A vertical shaft turbine requires less floor space and is generally preferable for low heads where it is necessary to set the turbine down near the level of the tail water. Horizontal shaft turbines are more desirable for any situation where it is practical to use them on account of greater accessibility, less bearing trouble, capability of direct connection to horizontal generators and adaptability of power transmission to horizontal shafting.

Which End of Cylinder Receives More Steam?—When there is the same percentage of clearance, the same back pressure of the exhaust and the same power develop(d in each end of an engine cylinder, which end receives the greater amount of steam?

O. H. D.

With the cutoff of the head end occurring at the most economical point or later in the stroke, the less piston displacement in the crank end of the cylinder due to the presence of the piston rod, would require a higher mean effective pressure for development of the same power; hence with the same initial pressure there would be a later point of cutoff and less benefit from working the steam expansively in the crank end of the cylinder and consequently more steam would be required for developing the same power.

Required Voltage—How is the electromotive force found which will force 15 amperes through a 60-cycle circuit having a resistance of 15 ohms and an inductance of 0.08 Henry?

S. C.

Solution is by the formula

$$E = I \sqrt{R^2 + (2\pi fL)^2}$$

in which

E = Electromotive force;
I = Current;
R = Ohms resistance;
f = Frequency;
L = Inductance in Henrys;
π = 3.1416.

Substituting we obtain:

$$E = 15 \sqrt{15^2 + (2 \times 3.1416 \times 60 \times 0.08)^2} = 505 \text{ volts.}$$

Mechanics Problem—If two men are to carry a weight of 250 lb. on a pole 10 ft. long, where must the weight be hung to let one man carry only 25 lb.?

P. J. M.

The other man must carry

$$250 - 25 = 225 \text{ lb.}$$

The distances from the point where the weight is suspended to the points held by each man will be inversely proportional to the two weights, and 25 being contained in 225 nine times, the distances will be 1 to 9, or the total 10. Therefore, if the weight is put 1 ft. from the man who carries 225 lb. the other man would only have to carry 25 lb., his distance being 9 ft. from the weight. Problem 26, answered in Lesson VII of the Engineers' Study Course on Elementary Mechanics, page 642 of the May 5, 1914, issue, was a similar problem.

Clearing Obstructed Water Pipes—How can incrustations or deposits in water-supply pipes be removed without using a solvent which would impair the potability of the water supply?

C. G.

For clearing large water pipes various forms of mechanical cleaners are employed which are forced through the pipes and are operated by water pressure. These loosen the scale and tubercules by the action of revolving or vibrating cutters. Service pipes 1¼ in. and less in size, which have become clogged by soft deposits or obstructed from the formation of tubercules, have been successfully cleared by forcing through them wads of manila tissue paper rolled into small crumpled balls of dry paper, which are introduced at the pipe outlet and are forced, one at a time, back into the main by means of water discharged from a hand force pump connected at the pipe outlet. When a pipe is cleared in this manner the wads introduced should be gradually increased in size, and the flow should be tested after each paper ball is forced through the pipe.

Spacing Flange Bolt Holes—What is the rule by which to set dividers to lay off the centers for any number of bolt holes in a flange? For example, how would nine holes be spaced on an 18-in. bolt circle?

W. F. L.

The finding of the exact distance between bolt holes on a flange circle is generally a matter of cut and try. We would suggest the following as the best method: Get the circumference of the bolt-hole circle by multiplying the diameter by 3.1416; divide this by the number of bolts. Space off with dividers, set to some fraction of this distance, the number of steps it is necessary to go from point to point along the circle and having determined the distance between the holes, set the dividers with a point on each center and lay off the rest of the bolt holes directly. If there is a slight error in completing the circle, divide this error by the number of holes, reset the dividers, and lay off again. For example, to space nine bolt holes in an 18-in. circle, the procedure might be as follows: The circumference of the circle will be

$$18 \times 3.1416 = 56.55.$$

This divided by 9 would equal 6.28, or very nearly 6¼ in. Setting the dividers at ¼ in., lay off this space (6¼ ÷ ¼ =) 25 times along the circumference. The distance between the two ends of this arc will be the chord between the bolt holes and the dividers can be set directly at this distance and the rest of the holes laid out at once.

Engineers' Study Course

Elementary Mechanics--XX

LAST LESSON'S ANSWERS

86. If it were not for the force of gravity the distance the plate would move in T sec. would be UT ft.; but during the same time gravity acts and retards the motion of the body by an amount equal to $\frac{1}{2}\ gT^2$; therefore the total distance passed over by a body projected vertically upward may be found from the equation,

$$S = UT - \tfrac{1}{2}\,gT^2 \qquad (50)$$

where

U — the initial velocity of the body in feet per second;

T = The total time of flight in seconds.

If the value of S should work out negative it means that the body had reached its highest point and had returned to the ground before the completion of the assumed time. Furthermore, the above equation does not state whether the body is rising or falling, but this may be determined by ascertaining the time of ascent from the equation $T_1 = \frac{U}{g}$. In this problem

$$T_1 = \frac{100}{32} = 3+ \ sec.$$

Hence at the end of the second second the plate is still rising, and its height from the ground is found thus:

$$S = UT - \tfrac{1}{2}gT^2 = 100 \times 2 - \tfrac{1}{2} \times 32.16 \times 2^2 = 135.7 \ ft.$$

87. The density of water is the mass of a cubic foot of water, and at about 39 deg. F. is 62.4 lb. per cu.ft.

The density of coal varies, depending upon the size and kind of coal. An average value for anthracite coal is 96 lb. per cu.ft. When piled in heaps the density will average about 55 lb. per cu.ft.

The *specific gravity* of a material is its weight compared with an even volume of water. Thus the density of wrought iron is 480 lb. per cu.ft., but its specific gravity is $\frac{480}{62.4} = 7+$.

88. From equation (47) $F = M \times a$. In this case the mass is 100 lb. and the acceleration is 4 ft. per sec., hence the force F in poundals is equal to $100 \times 4 = 400$.

89. The weight of the flywheel is 10 tons, or 20,000 lb. When the wheel is suspended from the crane hook the tension in the cable is 20,000 lb. (neglecting the weight of the block, cable, etc.), but when the weight is being put in motion the tension in the cable is increased an amount equal to the force which is required to overcome the inertia and to give the desired acceleration. This force may be found from equation (49), where

$$F = \frac{W}{g} \times a$$

$$F = \frac{20{,}000}{32.16} \times 1.25 = 777.4 \ lb.$$

Therefore, the total pull in the cable while the load is getting under way is equal to

$$20{,}000 + 777.4 = 20{,}777.4 \ lb.$$

90. When the flywheel is coming to rest its inertia will tend to reduce the tension in the cable. The force of inertia will equal

$$\frac{20{,}000}{32.16} \times 2 = 1244 \ lb.$$

and the tension in the cable is equal to

$$20{,}000 - 1244 = 18{,}756 \ lb.$$

WORK

A force is said to do *work* when it overcomes a resistance and causes an object to move in any given direction, or, as commonly expressed, *work is the overcoming of a resistance through a definite distance.* A horse moving a loaded van does work; the steam acting on the piston of an engine, by overcoming an external resistance, does work. An engineer may tug at the flywheel to move his engine off dead center, but no work will be done unless he has sufficient strength to turn the wheel. Hence the idea of work involves two fundamental notions; first, that of a resistance, and second, the overcoming of this resistance so that motion results. Moreover, the force exerted must be measured in the direction in which the resistance moves. There can be no work done on a body unless the body is put in motion.

The unit of work is the foot-pound. Thus, if a weight of one pound is raised through a vertical distance of one foot, the work done is one foot-pound; if the weight was 500 lb. and the distance 5 ft., the work done would equal 500×5 or 2500 ft.-lb. *The element of time does not enter into the idea of work;* thus the work done in raising the 500 lb. through the vertical distance of 5 ft. is 2500 ft.-lb., irrespective of whether it takes one minute or one hour to raise the weight.

A general equation for work may be expressed as follows:

Let W = the work done in foot-pounds,

F = the resistance overcome in pounds,

S = the space passed over by the resistance in feet,

then, since work = force × distance,

$$W = F \times S \qquad (51)$$

A careful distinction must be made between the terms resistance overcome and the weight of the body moved.

Where bodies are raised in a vertical direction there the resistance overcome and the weight are equal to each other. Take, for example, a clam-shell bucket used for raising the coal from the barges to the bunkers of a power house. Here the resistance overcome by the hoisting engine is the weight of the bucket and the coal it contains. When this coal is placed in the distributing cars over the bunkers the force exerted by a cable to move a car is not equal to the weight of the car and its load, but to the force of friction between the car and the track. This force of friction is decidedly less than the weight of the car. When objects are moved along horizontal surfaces, the resistance overcome seldom equals the weight of the object moved. Hence in figuring the work done by a force in moving an object through a given distance the essential thing is to determine the resistance overcome and then the work may be readily determined.

Example—A clam-shell bucket loaded with coal weighs three tons. How many foot-pounds of work will it require to raise the bucket a vertical distance of 200 ft.?

Here the resistance to be overcome is 6000 pounds and the distance is 200 ft., hence the work done is equal to

$$6000 \times 200 = 1{,}200{,}000 \ \textit{ft.-lb.}$$

Example—Find the work done by a fireman in moving a coal truck weighing 1000 lb. across the floor of a boiler room 100 ft. wide, assuming the friction between the truck and floor as 50 lb. per ton.

In this problem the resistance overcome is not the weight of the car, but the friction between the car and the floor, which is equal to

$$\tfrac{1}{2} \times 50 \ \textit{or} \ 25 \ \textit{lb.}$$

since the car weighs one-half of a ton. The work done by the fireman is then equal to

$$25 \times 100 = 2500 \ \textit{ft.-lb.}$$

POWER

Power is the time rate of doing work or is the capacity of an agent for doing work at a uniform rate. The more work an agent can do in a unit of time the greater will be its power. The commonly accepted unit of power is the horsepower, which is the equivalent of 33,000 ft.-lb. of work being done every minute, or 550 ft.-lb. every second. This unit was named and adopted by Watt, as he figured that an ordinary dray horse was capable of doing 33,000 ft.-lb. of work per minute. Throughout this work the term horsepower will be expressed by the symbol *hp.*

Example—In the case of the clam-shell bucket the work done was 1,200,000 ft.-lb. If the load had been raised in one minute, then the horsepower required would equal

$$\frac{1{,}200{,}000}{33{,}000} = 36.3 + \textit{hp.}$$

If the work had required 3 min. the hp. would have been only 12.1, so that the greater the time the less will be the power required to do a definite amount of work.

Let T = the time required to do a certain amount of work,
F = the resistance overcome in pounds,
S = the space passed over by the resistance in feet,
$hp.$ = the horsepower required, then

$$hp. = \frac{F \times S}{T \times 33{,}000} \qquad (52)$$

EFFICIENCY

A machine is a device for the performance of useful work. Generally the machine will be supplied with power from some external source, and experience teaches that it is impossible to convert all the power supplied into useful work. There are numerous losses in the machine itself, such as the friction in the bearings, the loss in gears and belts, friction between sliding parts, and many others too numerous to mention. The power supplied to the machine (commonly called the input) must equal the losses in the machine plus the power developed by the machine (commonly called the output).

The *efficiency* of a machine is expressed in terms of the per cent. of the input converted into useful work or put in the form of an equation:

$$\textit{efficiency} = \frac{\textit{output}}{\textit{input}} \qquad (53)$$

Example—Assume the efficiency between the engine and the bucket (in previous example) to be 60 per cent. What horsepower engine would be required to raise the bucket?

The power required at the load was found to be 36.3 hp. As this, (the output) represents only 60 per cent. of the input, it must be evident that the horsepower of the engine must be equal to the output divided by the efficiency, or

$$\frac{36.3}{0.60} = 60 \ \textit{hp.}$$

STUDY QUESTIONS

91. The average unbalanced steam pressure on the piston of an engine is 35 lb. per sq.in. If the diameter of the piston is 9 in. and the stroke of the engine is 12 in., find the work done by the steam in one revolution of the engine. (Assume the engine to be double acting.)

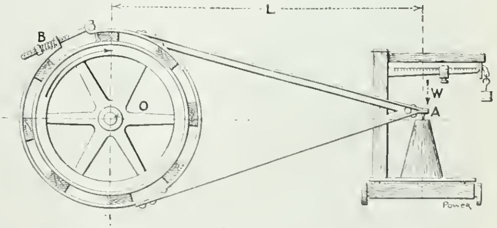


FIG. 66.

92. In problem 91, if the engine makes 250 r.p.m., find the horsepower developed in the engine cylinder.

93. Fig. 66 shows a common form of prony brake used in the testing of engines. During a test of the engine in problem 92 the length of the brake arm L was 5 ft., the net load on the brake was 120 lb. Find the horsepower developed at the brake.

94. From the results of problems 92 and 93 find the mechanical efficiency of the engine.

95. Explain what becomes of the power developed at the brake. Is it possible for the brake-horsepower to be greater than the power developed in the engine cylinder?

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Cost per Square Foot for Building Upkeep—The cost per square foot of rentable area for the upkeep of skyscraper office buildings says "Building Management," no doubt varies greatly in New York. A table recently prepared by C. T. Coley, the operating manager of the New Equitable, has inspired Vice-President Mortimer of the U. S. Realty & Improvement Co. to prepare a table showing average costs per square foot of rentable area in some of the first-class buildings of New York, as he found them, covering a period of five years:

Engine-room labor, supplies, etc.	$0.052
Coal and ash removal	0.067
Elevator labor, supplies and repairs	0.050
Janitor's labor and supplies	0.094
Electrician's labor and supplies	0.010
Supervision	0.016
Repairs to building and plant	0.032
Tenant changes and alterations	0.040
Building supplies, gas and sundries	0.008
Insurance	0.011
Water	0.009
Total	$0.389

T. Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—A colliery power plant is inspected, in which, by the installation of a low-pressure steam turbine, surface condenser and cooling tower, the capacity of the plant was practically doubled. The saving in coal amounted to about $400 per month, although the electrical load increased about 40 per cent. over former conditions.

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Early the next morning Hunter and I made a start to visit the workings of the Penn Mary Coal Co., at Heilwood, Penn. This necessitated a ride by train of some miles, which gave us opportunity to talk shop. Hunter, as usual, made for the smoking car and lighting an apology for a cigar, I never determined its brand, settled himself as comfortably as he could.

Evidently his thoughts were running in the same channel as my own, for he presently knocked the black ashes from the end of the stuff he was smoking and said, "The mine operator has got his work cut out for him when he begins to consider either building a central power plant or purchasing the electrical energy from a central station to replace the old steam plants.

"The ghost of cost looms up at every turn. In the first place, he believes that power has been produced at a reasonable cost; whether it has or not, is another question. It is true the fuel is cheap and the apparatus in the old steam plants is of the most simple type, but he cannot get over wondering what it will cost under the new order of things if the change is made. In most cases the private central station is constructed."

"I should think that purchasing energy from a central station would remove the bother of operating a power plant, and then all that would have to be done would be to ship the coal and collect the cash."

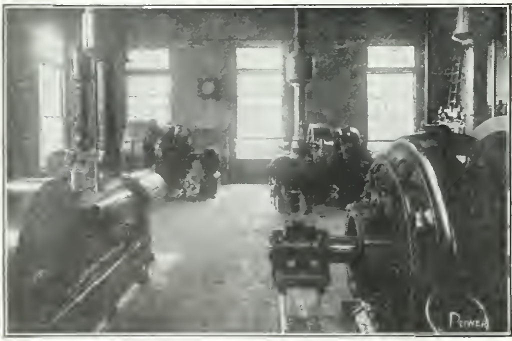

Fig. 1. Old Engine Room and Reciprocating Engines

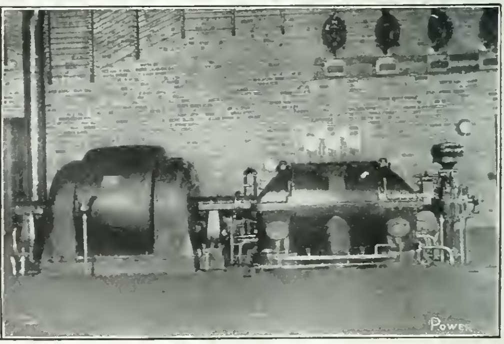

Fig. 2. Low-Pressure Exhaust Steam-Turbine Unit

"That sounds good, but there is no reason that I can see, why the coal producer should not build and operate his own plant, and produce an electrical output as cheaply, if not cheaper than it can be purchased.

"I believe I told you a few days ago that the general run of colliery steam boilers were a source of great loss, let alone the condition in which the various engines and pumps are run. Some operators have awakened to the fact that where fuel was a few years ago worth about 30c. a ton, it is now worth about 80c. a ton."

At this point in Hunter's discourse, the train pulled into the station and we were soon climbing the steep hill, and it was steep. A barnstorming company playing in "The Old Homestead" made the climb at the same time, but although they had doubtless had more practice, we outdistanced them to the hotel. After something to eat, we hunted up the superintendent of the colliery and obtained permission to look over the power plant, down at the foot of the hill.

The interesting feature about this installation was doubling the output without increasing the coal consumption. This was done by installing a low-pressure steam turbine, which uses the exhaust steam from the reciprocating engines which had before that exhausted to the atmosphere.

"You see," said Hunter, "in the colliery, because of the steep grades, in some instances 5, in others 16 per cent., motors are assisted by electric hoists. The motor is used to unwind the cable and pull the empty cars into the mine where the slope in the grade decreases; on the outward trip, the motor pushes the trip, both cable and motor working together.

"Before the changes were made the generating equipment consisted of four 18x22-in. side-crank engines, each directly connected to a 200-kw., 250-volt direct-current generator, at 225 r.p.m."

"I thought you said the other day that alternating current was generated at the power plant and changed to direct current at each mine."

"So I did, but when the original equipment was installed, direct current was the best to use, as the workings were close to the power house. When these workings got further away from the power house, it became as plain as the nose on your face that some provision must be made to transmit the electrical energy to the distant parts of the mine. Therefore the turbine and alternating generator were installed."

Arriving at the plant, we entered the old engine room, Fig. 1, in which the reciprocating engines were housed. At the end of this room is the turbine room, where a 750-kw. exhaust-steam turbine was installed, Fig. 2. The generator end produced energy at 2400 volts, three-phase, 60-cycle current at 3600 r.p.m.

Out in the boiler room were the four original water-tube boilers and two new water-tube boilers, Fig. 3, each of 300-hp. rating, and carrying 125-lb. steam pressure. The brick stack was 125 ft. high.

In the turbine room there was a 25-hp., 250-volt balancing set.

"When it became evident that more power was wanted," resumed Hunter, as we stood looking at the turbine unit, "it became a question of either having one power plant or several distributed at the mines.

"We have already said the latter method is not economical and a study of the situation showed this to be the case in this instance. Then the matter of deciding how to increase the output of the plant with the least outlay had to be settled. The result was that the direct-current units supply the works near the power plant with direct current and the exhaust-steam turbine and alternating-current generator supply high voltage energy for the distant workings.

Fig. 3. The Two New 300-Hp. Water-Tube Boilers

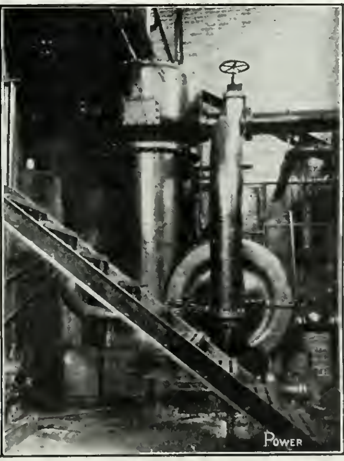

Fig. 4. Leblanc Condenser Serving Exhaust Steam Turbine

Fig. 5. Exterior View of Air-Cooling Tower

"The reciprocating units exhaust into a common exhaust line which runs to the turbine, and also has a live-steam connection so that the turbine can be run in case all of the engines are shut down, and there is no exhaust steam for the turbine to use."

"How can a turbine run on exhaust steam and double the output of the station?"

"It does seem a little off color at first thought, but it's as plain as daylight after you once get the hang of the thing. You see those engines were exhausting to the atmosphere at, say, 2-lb. back pressure on every square inch of the piston area, or practically 17 lb. absolute pressure. Now all of that pressure that can be eliminated will tend to increase the horsepower output of the engine.

"When the turbine was connected to the exhaust pipe of the engines and was piped to a condenser on the other side, the steam from the engines went to the condenser just the same as if the piping had been direct, instead of through a turbine. The back pressure was reduced in proportion to the vacuum carried which if 28 in. would reduce the absolute pressure in the turbine exhaust pipe pipe to less than one pound, or 0.946 lb. per sq.in. That makes a difference in the absolute exhaust pressure of 16.054 lb. per sq.in. over what the engines did exhaust at and the pressure at what the turbine exhausts.

"It is the exhaust steam from the reciprocating engines rushing through the turbine to the condenser (Fig. 4) that governs the additional power.

"Of course the condenser has to be supplied with sufficient cooling water, which in this case is not plentiful, and for that reason a cooling tower is used to reduce the temperature of the water after passing through the condenser."

"That's funny, a cooling tower at a mine where all kinds of water can be had for the pumping. Why don't they pump the mine water to the condenser and kill two birds with one stone?"

"You forget," answered Hunter, "that mine water is mighty hard on condensers, and that by using a cooling tower, the water can be used over and over in practically a pure state. It was found, at this mine, that using a cooling tower is more economical than the method you suggest, or even than obtaining the necessary water by pumping from a deep well."

"It takes power to drive the fans, doesn't it?" I next asked, "and that detracts from the saving made by using the turbine. It seems to me that with the cost of the turbine, condenser and cooling tower the gain made by using exhaust steam would be offset by the additional cost of the new apparatus."

"The cost would amount to considerable. On the condenser, there would be the circulating and air pumps, which are operated by a steam turbine, the exhaust of which is used to heat the feed water going to the boilers. Then there would be the 18-hp. motor required to run the air fan at the cooling tower, which delivers the air to the water as it trickles down through the tower. In winter the problem is to prevent ice forming at the fan intake, and so each fan is surrounded by a ring of pipe perforated with small holes through which steam escapes when there is a tendency for ice to form.

"These all take from the economy of the power plant, but for all that, I understand over $400 a month has been saved in the cost of coal since the turbine outfit has been running, over the cost of operating with the old conditions for similar months, although the electrical load has increased something like 40 per cent."

"Of course the alternating current is sent to the substations and there converted to direct current for mine use," I said as I put my camera in its case.

"Sure! There are two substations, each containing a 300-kw., 250-volt generator, driven by a 450-hp. synchronous motor. This electrical energy is used for lighting, electric haulage, electric pumping and ventilating fan motors."

As it was getting along toward train time, and not caring to take in "The Old Homestead" show, we said "So-long" to the boys at the plant and were soon rumbling on our way.

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Installing and Starting Centrifugal Pumps

By William Salt

SYNOPSIS—What to do and what may lead to trouble in erecting and starting centrifugal pumping outfits.

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Many visits to correct supposed pump troubles, which later proved to be faults of installation or operation, suggest the following as being of interest to users of centrifugal pumps.

Unpacking

The centrifugal pump, whether arranged for motor, turbine or belt drive, is usually mounted on the bedplate with the driver, making a complete unit. Therefore, when unpacking, guard the apparatus against shocks or blows that might injure the parts. Use a rope or a chain if possible under the bedplate when lifting the complete machine, and keep the suction and discharge openings blanked until ready for the pipe connections to insure a clean pump when starting.

Foundations

The foundation should be solid enough to prevent the distortion of the bed or base plate. Masonry or concrete foundations are preferred to wooden supports. Foundation bolts are not necessary with a solid foundation when motor or turbine drive is used, but they should be used with the belt or engine drive.

Erecting the Outfit

The driving and pump shafts should be level and the bearings properly lined with each other. When separate shafts are used the couplings should be disconnected by removing the bolts, and the final alignment of the machine carefully checked by using a straight-edge or scale on the outer diameter; a thickness gage between the bases will show if the couplings are true with each other.

Piping

Care must be taken in making up the piping at the pump to prevent strains in the case or bedplate. After the piping is completely made up on the system, the joints at the suction and discharge should be loosened to see that the faces are parallel and that the piping lines up properly. Excessive piping strains will distort the case and throw the shaft out of alignment. When handling hot liquid, care must be exercised in planning the piping system to prevent strains due to expansion.

When using a siphon or injector for priming, it is necessary to have a valve in the discharge piping. This valve is usually at some convenient point near the pump, the minimum distance being two to three feet, to give the best results in starting. The connection to the siphon should be made at the top of the pump case and at the highest point in the discharge pipe between the check or stop valve and the pump.

With a foot valve on the suction, the pump and piping should be primed with water from the general supply system. An air vent valve must be put on top of the case at the highest point in the discharge pipe below the check or stop valve. The suction pipe must have a gradual drop from the pump to the intake to prevent air pockets, which would give trouble in starting and during the operation of the pump.

Sealing the Glands

Packing boxes are often fitted with a spacer between the packing directly under the pipe tap holes in the upper half of the case or with channels leading to the discharge chamber of the pump case. When arranged for outside pipe connection the pipe should connect with the water-supply system beyond the discharge valve of the pump to furnish sealing water when starting and during operation. If the pump is handling dirty or gritty water that would cut the shaft, clean or filtered water should be fed to this point if possible. If the packing boxes are not water-sealed, greater care must be had in fitting and adjusting the packing.

Starting the Pump

See that the machine is thoroughly cleaned; fill the oil reservoirs with a good quality of mineral oil, being sure that the oil level is high enough to insure the rings giving the right supply of oil to the bearings. When the pump is attached to a motor, or is belt driven, that pump must have the proper rotation; this is indicated usually by an arrow on the casing, or is given on the instruction card. If operated in the opposite direction the pump will give trouble, as most of them are designed for one direction only. With a motor-driven pump the coupling bolts should be taken out before testing the motor for direction of rotation.

When correct rotation has been determined, the pump is ready to be coupled to a driver and must be primed so that the case will be thoroughly filled with water before testing out for its service condition.

Michigan N. A. S. E. State Convention

On July 15 to 17 Michigan's annual state convention was held at Muskegon. Arbeiter Hall was headquarters for the engineers and exhibitors. The invocation, by the Rev. A. Hadden, was followed by the address of welcome, delivered by Mayor John H. Moore. F. W. Raven, national secretary, responded and John McGrath, past national president, gave a general talk on the purposes of the organization. In the afternoon the engineers enjoyed a boat ride on Muskegon Lake and inspected the plant of the Central Paper Co.

The feature of the Thursday morning session was an address by F. E. McKee, general manager of the Shaw Electric Crane Works, on the subject, "Industrial Education." Mr. McKee favors the alternate weekly system, in which the rudiments of molding, printing, turning, etc., are obtained in the school and the actual experience in different shops where the student is sent to apply his knowledge. The speaker also discussed the safety of employees. Owners of factories were just as anxious for the safety of their employees as they were themselves. He favored laws for safety, just laws which would not eliminate features tending toward economy in production. At 2 P. M. the engineers left by trolley for Recreation Park. Boat rides were taken on Lake Harbor, but most of the conventioners attended the ball game between the engineers and exhibitors. The result was a disastrous rout for the latter, the score being 20 to 6.

On Friday Jackson was chosen as the convention city for 1915. The following officers were elected: President, John Andrews, Pontiac; vice-president, Fred Tech, Flint; secretary, E. C. Smith, Kalamazoo; treasurer, Henry Badley, Owosso; conductor, George Maloney, Jackson; door-keeper, Edward Rose, Detroit; state deputy, W. H. Moore, Detroit; trustee for one year, C. H. Sisson, Muskegon; for two years, William Mauthe, Muskegon; for three years, Charles White, Detroit.

In the afternoon there were special cars to Lake Michigan and later to Recreation Park, where a fish supper was served, followed by dancing.

THE EXHIBITORS

Below are given a list of the exhibitors:

American Steam Gauge & Valve Co.
The V. D. Anderson Co.
Arrow Boiler Compound Co.
Bowers Rubber Works
Buckeye Chemical Co.
Craig-Millard Co.
Crandall Packing Co.
Dearborn Chemical Co.
The Garlock Packing Co.
Grand Rapids Supply Co.
Greene, Tweed & Co
Griscom-Russell Co.
Hawk-Eye Compound Co.
Home Rubber Co.
J. J. Howdin Co.
Jenkins Bros.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Lagonda Mfg. Co.
The Lunkenheimer Co.
H. Mueller Co.
"National Engineer"
The Perolin Co. of America
William Powell Co.
"Power"
Standard Oil Co.
Towner Hardware Co.
White Star Refining Co.

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New York Engineers' Fight on the Central Station

Feeling it necessary to combat the aggressiveness of the local electric service company in attempting to suppress isolated electric plants, the New York members of the National Association of Stationary Engineers and the International Union of Steam Engineers, as well as a number of local engineers' societies, have formed "The Joint Committee of Greater New York Engineers." The investigations so far undertaken, according to a circular recently published, have developed the following:

PROCEEDINGS BEFORE THE PUBLIC SERVICE COMMISSION

In Case 1[illegible] brought by the Joint Committee as attorneys in fact of over [illegible]0 small consumers against the New York Edison Co., the schedule of rates established by the company July 1, 1911, was attacked as long ago as September, 1911. The following facts were proved:

a. That the Public Service Commission affords a tribunal before which the customers of public service corporations can force the corporation to make public under oath information necessary to be known by the customer in order to deal intelligently with the corporation and which, without the machinery of the Public Service Commission's law, the customers could not secure in any accurate form.

b. That the Public Service Commission will undertake for consumers and the community generally a public investigation into the rates and contract requirements of public service corporations with a view to correcting discriminatory and other illegal practices.

c. That the New York Edison Co., under its existing rates, is unable to compete with an efficient private plant in supplying electric current, and can prevent the installation of private plants in large buildings only:

1. By resorting to rates and forms of contracts which have not been made public and which therefore are illegal and in violation of the orders of the Commission; or

2. By compelling the making of an uneconomic contract through the exercise of ulterior influences; or

3. By making contracts through subsidaries for the supply of light, heat and power on a flat annual basis; or

4. By establishing a minimum wholesale rate of 2 cents per kilowatt hour for large consumers, which rate would be far below cost.

d. That the attempts to give unpublished low rates to Gimbel Brothers and the Bowling Green Building through the subterfuge of paying exorbitant rent for underground space in the customer's premises, are illegal and void.

e. That published contracts through the non-enforcement of which discrimination was attempted in favor of big contractors to induce them to use electricity as the sole source of power, will be strictly enforced and the attempted discrimination thus prevented.

f. That subsidiary corporations making contracts for the supply of light, heat and power for a flat annual price will be regulated as to rates and contract forms in the same manner as other public service corporations.

g. That the New York Edison Co. is controlled through stock ownership by the Consolidated Gas Co., which is seeking to perfect a monopoly of the supply of gas and electricity throughout Greater New York and Westchester County, and that the effort to make electricity generated in central Manhattan stations the sole source of energy in that territory is but a part of the process in the formation of an electric power monopoly throughout the nation to which warning attention has already been called by the United States Commissioner of Corporations.

AQUEDUCT FRANCHISE APPLICATION

The Joint Committee have opposed the application of the New York Edison Co. and its three affiliated companies to the Board of Estimate and Apportionment of the City of New York for a franchise or right of way over all the lands acquired by the City for aqueduct purposes. A written argument in opposition has been filed with every member of the said Board and with the Secretary thereof and the Chief of the Bureau of Franchises. But for this opposition, apparently, the application would not have been opposed. Attention has been called to the following facts among others:

a. That the application is a part of the same policy above referred to, by which the Consolidated Gas Co. seeks to perfect a monopoly of the electrical business in this City and Westchester County.

b. That even if the City of New York in its four aqueduct lines through Westchester County has rights of way which can be used for transmitting electric current to be sold off the rights of way for general commercial use, such rights of way are of such tremendous value that they should be retained under public control and not alienated to private interests for any length of time or on any terms.

c. That if, however, such rights of way are to be alienated to the New York Edison Co., the City should receive every year as compensation for the priceless privileges granted, a large share of the benefits taken by stockholders and others out of the electric earnings of that company (in 1912 $12,890,041.83). In this way the oppressed taxpayer will receive substantial relief.

⁂

New York Steam Co. Ordered to Replace Mains

Claiming that the high-pressure mains of the New York Steam Co. are a source of damage to the block pavements, sewers, water mains and the waterproofing of the subway, the Public Service Commission has ordered the company to replace its 10½ miles of old brick trench construction with modern tile construction. A period of five years is allowed for the completion of the work, during which time not less than 12,000 ft. must be replaced each year. The cost of the replacement is estimated at about a million dollars.

The original mains were laid in a trench with brick walls 8 in. thick, the pipe being supported on iron saddles placed on brick piers. The pipe was surrounded by mineral wool and planks covered with tarred paper were placed over the trench. Trouble was experienced with water leaking in and flooding the mains, so about five years ago the plan was adopted of making a continuous drainage under the trench. The latest trenches put in by the company are of 9-in. hollow tile.

The proceedings were instituted on the motion of the commission after its engineer of substructure had made a careful study of the conditions and reported that it is a common occurrence to find the earth for some feet outside the brick walls of the steam mains filled with steam which escapes when the earth is disturbed. Temperature measurements at these points had shown from 85 to 190 degrees in winter. The leather washers in water hydrants were found burned so that the water discharged from some of the high-pressure hydrants hot enough to give off steam. Moreover, the unsatisfactory condition of the wood-block pavements in many instances was traceable to this cause, and was responsible for excessive maintenance cost. He further found that at every street intersection the waterproofing of the Broadway subway has been damaged by heat from the steam mains the asphalt having practically disappeared and the fabric dried up and cracked.

This testimony was corroborated by inspectors from the Department of Water Supply, Gas and Electricity and the Department of Public Works, who added that the temperature in the manholes adjacent to the steam mains was often such as to render it impossible for men to work in them. A representative of the New York Edison Co. also testified as to cables having been injured and their capacity reduced because of the high temperatures from the steam mains.

The business of the New York Steam Co. dates back to 1881 when it was formed with an authorized capital of $7,500,000 to take over the franchise of an earlier company which, however, had done no operating. In 1885 its downtown plant, station B, was built in the block bounded by Cortland, Dey, Greenwich and Washington Sts. This has a rated boiler capacity of 15,800 hp., and serves 29,559 lin.ft. of mains at a boiler pressure of 95 lb., which drops to 70 lb. at points farthest from the station. The uptown district is served by station J, built in 1897 at the foot of East 59th St. An extension was added to this plant in 1908, making its total rated boiler capacity 16,500 hp. From this source 37,561 lin.ft. of mains is supplied at a boiler pressure of 55 lb., dropping to 40 lb. at the farthest points.

In all there is about 12.7 miles of mains served by the New York Steam Co., the steam in the downtown district serving 456 customers and being about equally divided between heat and power. That in the uptown district serves 625 customers, and is used almost exclusively for heating. Both a flat rate and meters are employed, the maximum rate being $2 per thousand pounds and the minimum 47c. In the uptown district where a large number of customers are charged a flat rate, the charge from Oct. 1 to June 1 is $3.50 per 1000 cu.ft. contents of the building, based on outside dimensions.

In addition to the heating plants the New York Steam Co. owns three ice plants, the "Blue Star" adjacent to station B, the "White Star" at 525 East 18th St., and the "Red Star" at 514 East 116th St. In the first of these the water from the ammonia condensers is used for steam generation.

The hearings before the Public Service Commission have established the ownership and control of the New York Steam Co., about which there has long been much speculation in the mind of the public. It appears that about two thirds of the stock is held by the Andrews Institute for Girls, a charitable institution near Cleveland, Ohio. The president of the company, G. C. St. John, owns another large block and the remainder is held by about 130 small stockholders. It is said never to have paid any dividends, and the last sale of stock reported was at the rate of $1.50 a share.

BUSINESS ITEMS

The Vilter Mfg. Co., Milwaukee, Wis., has removed its Chicago District office from 802 to 731 Monadnock Block. C. J. Heinzelman will continue as district manager.

The Sullivan Machinery Co., Peoples Gas Building, Chicago, Ill., has established a new office at Juneau, Alaska in the New Brunswick Building. Burt B. Brewster for several years past associated with the St. Louis, Mo., office has been appointed manager.

The United States Government has recently placed orders for Mietz & Weiss oil engines for the following sizes: Seven 45-hp. compressor units, two 18-hp., one 7-hp., two 12-hp., and one 150-hp. M. & W. direct reversible marine engine. These engines are built by August Mietz, 128-138 Mott St., New York.

The Wiener Machinery Co., 50 Church St., New York, is sending to power-plant men interested in locomobiles, a copy of their splendid catalog fully describing the Lanz superheated steam locomobiles, portable and semiportable. It is a large, 110-page catalog, with handsome embossed cover, and contains many fine halftone illustrations. A request brings a copy.

Here's an interesting letter which the Penberthy Injector Co., Detroit, Mich., received the other day. "—My injector has played out. It has given 18 years of service and it was a Penberthy and I want another one. The one I have is size DD. In winter we carry 90 lb. steam pressure and in summer 20 lb. One hundred horsepower return tubular boiler and a water pressure of 45 lb., would the non-lifting automatic injector be all right? I think it would and could I get it with 1¼-in. connections? Yours truly, (Signed) E. G. Stewart, Fleming Street, Coraopolis, Penn.

NEW EQUIPMENT

ATLANTIC COAST STATES

The power plant at Pawtucket, R. I., of the Blackstone Valley Gas & Electric Co. was damaged by lightning recently. Loss, $30,000.

The Mercer County Light, Heat & Power Co., Greenville, Penn., will build a new power plant, to be located near the south end of the Bessemer Bridge over the Little Shenango River.

The Reading Coal & Iron Co. contemplates the construction of a high tension power house at Pottsville, Penn.

According to press reports, the City Council of Ocean City, Md., is considering the installation of a municipal electric-light plant to furnish electricity for a three mile lighting system on the board walk.

SOUTHERN STATES

Plans are being prepared by the Logan Electric Co. for the construction of a new power plant at Logan, W. Va. C. W. Poling, Logan, is Mgr. and F. R. Weller, Hibbs Bldg., Washington, D. C., is Engr-in-Charge.

The Purified Petroleum Products Co., Louisville Trust Bldg., Louisville, Ky., is in the market for a 20 hp. motor.

The Progress Laundry Co., Louisville, Ky., will purchase eight or ten motors ranging in size from 5 to 10 hp. M. A. Myers, Inter-Southern Bldg., is in charge.

CENTRAL STATES

The citizens of DeGraff, Ohio, have voted bonds for $7500 for the improvement and extension of the municipal electric-light plant. J. T. Scott is Supt.

Bids will be received by Ernest Von Bargen, Pur. Agt., Cincinnati, Ohio, until noon, Aug. 5, for furnishing and installing new boilers in the City Hall.

The Westinghouse, Church Kerr Co., 37 Wall St., New York, N. Y., has prepared plans for the construction of an electric-light plant for the Mahoning County Light Co., Youngstown, Ohio. Estimated cost, $1,000,000.

The Chief Engineer of the City Hospital of Indianapolis, Ind., has petitioned the Board of Health to make improvements and extensions to the power plant of the hospital. Estimated cost, $17,000.

The Utility Power Co. will install a power plant in its new factory at Detroit, Mich. Preston, Brown & Walker, Dime Bank Bldg., Detroit, are Archs.

An expenditure of $25,000 is contemplated by the Bloomington & Normal Ry. & Light Co., Bloomington, Ill., for improving its power plant. M. G. Linn, Bloomington, is Gen. Supt.

The City Council of White Hall, Ill., is considering the question of installing a municipal electric-light plant.

WEST OF THE MISSISSIPPI

Bids will be received by L. D. Burgess, City Clk., until 1.30 p.m., Aug. 14, for the construction of a municipal electric-light plant at Larned, Kan.

The citizens of Kansas City, Kan., will vote Aug. 25 on the proposition to issue bonds for $650,000 for the improvement and extension of the municipal electric-light plant and water system. G. B. Little is City Clk.

The Iowa Ry. & Light Co., Cedar Rapids, Iowa, contemplates the construction of a new power plant at Iowa Falls, Iowa. Robert S. Cook, Cedar Rapids, is Pur. Agt.

Bonds for $7000 have been voted for the construction of a municipal electric-light plant at Billings, Okla.

CANADA

The Hydro-Electric Commission contemplates the installation of some new equipment in the power station at London, Ont. H. J. Glaubits is Mgr.

The City Council, Regina, Sask., will build a new power plant and extend its distributing system at a total cost of about $380,000. A. E. Chivers is Clk.

The ratepayers of Saskatoon, Sask., have approved a bylaw appropriating $15,000 for the purchase of a site for the construction of a new power plant.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance.

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books) and **For Sale**, 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

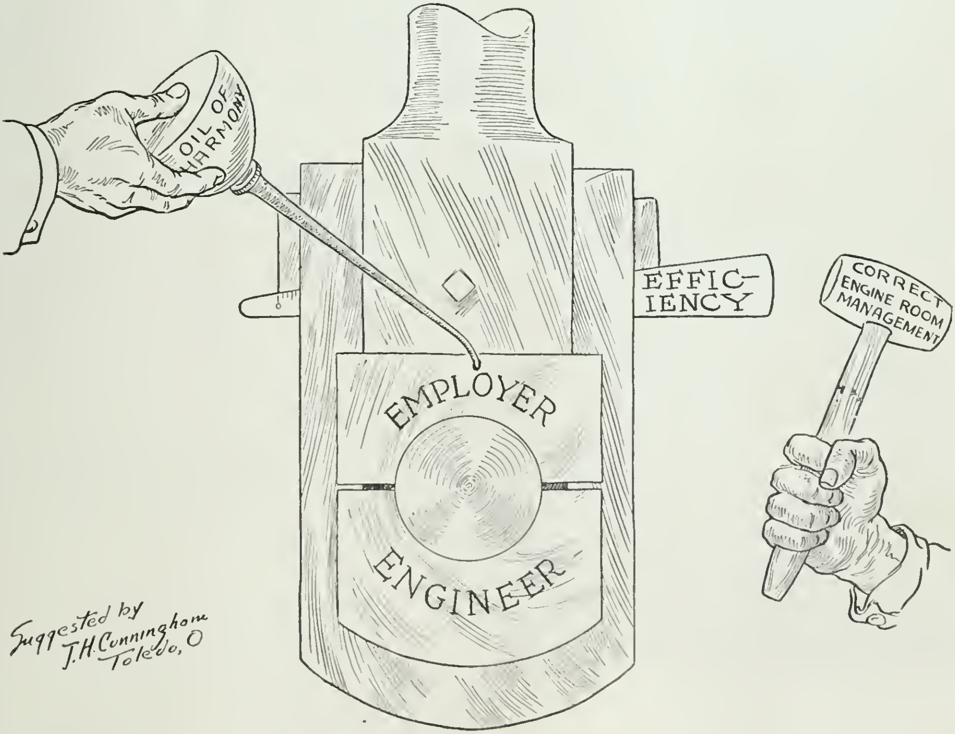
A MAN who can take charge, make repairs and adjustments on tandem gas engines wanted; all day work of six days per week; state experience and salary. P. 300, Power.

SALES MANAGER for New York territory wanted by steam turbine manufacturer; only first-class experienced salesmen need apply; to obtain consideration state fully in reply to this advertisement just what your experience has been. P. 296, Power.

MAN wanted to take charge of all maintenance work of a manufacturing concern employing about 300 hands; experience should be along the lines of power-station work, millwright work, piping work, erection of buildings, together with some experience as draftsman and in general office routine; state in your answer, age, nationality, salary and full particulars about experience and former positions within the last five years; factory is located in town of about 20,000 souls in New Jersey, one hour out of New York City. P. 299, Power.

POWER

Vol. 40 NEW YORK, AUGUST 11, 1914 No. 6


OIL OF HARMONY
EFFICIENCY
EMPLOYER
ENGINEER
CORRECT ENGINE ROOM MANAGEMENT
Suggested by T.H. Cunningham Toledo, O

A Smooth Running Bearing

Plant of Dime Saving's Bank Building, Detroit

By Thomas Wilson

SYNOPSIS—This is a model plant of 1000-kw. capacity designed to serve two office buildings. The older building has been taking central-station heat, light power and refrigeration. The plant in the new building will effect a large saving.

⁂

The largest office building in Michigan was recently erected at the corner of Griswold and Fort Sts., Detroit, by Edward Ford, of Toledo, Ohio. It is a handsome structure, 23 stories high, with two basements, and is built in the form of an "H" on a plot measuring 130x150 ft. The first floor is given over to the bank and a number of stores, and those above to 858 office suites, housing about 3000 people. The building, which appears in Fig. 1, is equipped with the latest services and has its own plant to furnish current for lighting, power and elevators, steam for heating, hot water for house use, refrigeration and vacuum cleaning. The Ford Building, another property under the same ownership, will also be served by the new plant. The two buildings are connected by a 7x7-ft. tunnel 500 ft. long, so that there will be no difficulty in carrying the mains and cables necessary to the older building. It has been supplied with electrical energy, steam and enough refrigeration to cool the drinking water by a public-service corporation and will continue to take these services until the contract expires two years hence. As a consequence, the new plant is underloaded for the time being and is not giving quite as good results as it will when carrying both buildings.

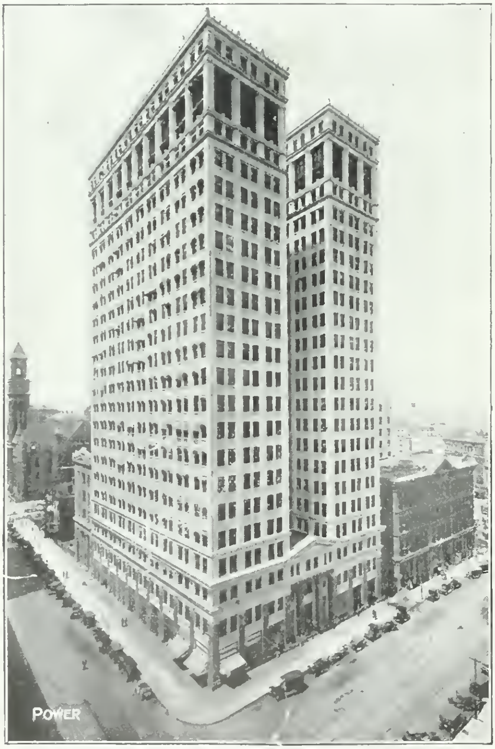


Fig. 1. Dime Savings Bank Building, Detroit, Mich.

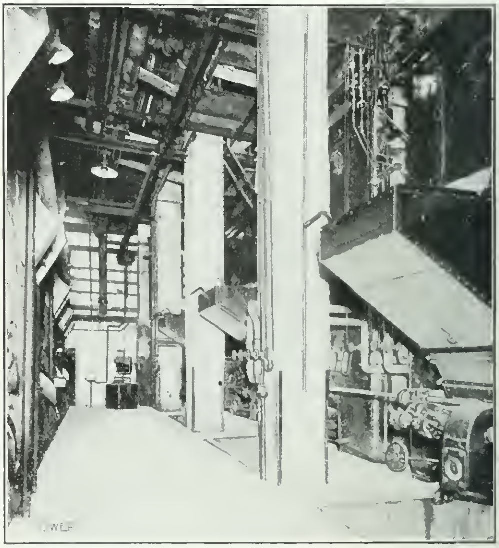


Fig. 2. Boiler Fronts and Coal Bunker at Left

Services Rendered by Plant

The Dime Savings Bank Building is equipped with 3400 sixty-watt lights, which total 204 kw. when all are in use. The power load consists of 29 motors for general use ranging from 3 to 60 hp., and nine elevator motors, eight of 25- and one of 30-hp. capacity. These high-speed, direct-traction motors take current at 220 volts. The car speed is 550 ft. per min. and the direct travel 268 ft. In February, the electrical load averaged close to 2200 kw.-hr. per day of 24 hr., which would call for a uniform generator capacity of less than 100 kw. The night and Sunday loads, however, are light, and during week days, when the elevators frequently impose heavy peaks, it is necessary to keep two 200-kw. units in operation, although for the greater part of the time one machine could handle the load.

For heating the building there are 47,000 sq.ft. of direct radiation and 16,000 of indirect serving the bank and a restaurant in the first basement. As much as possible of this is made up by the exhaust from the main units and the steam-driven auxiliaries. The balance is live steam supplied direct from the boilers through a reducing valve. Besides, live steam is supplied to the restaurant at 30-lb. and some at 6-lb. pressure to a 30-ton absorption plant to supplement the exhaust from the brine, aqua and drinking-water pumps.

In the Ford Building, which is 19 stories high and in plan measures 138x110 ft., there is a total connected motor load of 426 hp. besides the lighting. For an average the year around, the load will closely approximate that of the new building. Most of the power is required by the six hydraulic plunger elevators which have a travel of 212 ft.; during the day they are served by a 9x18-in. triplex pump driven by a 150-hp. motor. There are two other pumps, each 7½x12 in., of the same type, driven by 80-hp. motors, which are used singly for night service or in unison when the large pump is shut down. Besides, one of the smaller pumps is carried on the line continuously, but is set low so that it is not called into service unless something serious happens to the main unit. The pumps operate against an average pressure of 180 lb. and are set to cut out at 220 lb. There is also a triplex 5½x12-in. pump driven by a 25-hp. motor which serves a four-ton freight lift. For ventilating and exhaust fans there are six motors totaling 50 hp. Two house pumps and the ice-water circulating pump are each driven by 1-hp. motors, two circulating pumps on the air washers take 2 hp. each, the vacuum cleaner 15 hp.; for the sewage ejector there are duplicate sets of air compressors driven by 5-hp. motors.

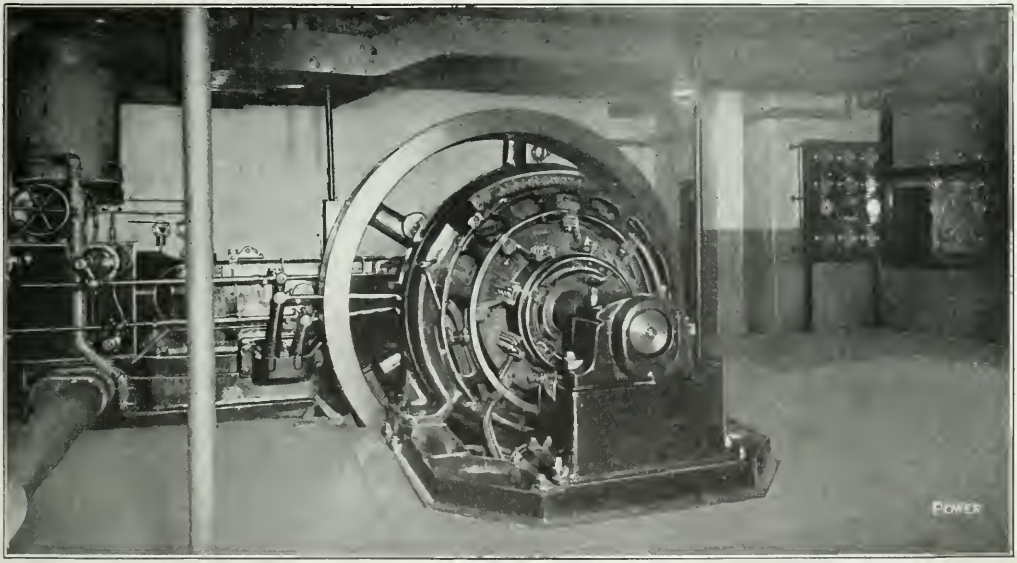


Fig. 3. One of the Generating Units and the Gage Board

The building has 38,000 sq.ft. of direct radiation served by a Paul system, which is now supplied with steam at 5-lb. pressure by the Murphy Power Co. To maintain the hot-water service, steam is required all the year round.

In the Dime Savings Bank Building the engine room is in the sub-basement, 32 ft. below the street level, the pump and fan rooms are in the first basement and the boiler room occupies a part of both. There is a total capacity of 1400 hp. in boilers, 1000 kw. in five generating units (a ratio of 1.4 to 1, respectively) and a refrigerating capacity of 30 tons. About half of the auxiliaries are steam driven and the balance is operated by motors. The electrical service is three-wire, direct-current.

Boiler Rooom

There are four water-tube boilers, see Fig. 2, each rated at 350 hp., which have 3500 sq.ft. of heating surface. The working pressure is 150 lb., with no superheat. Each boiler is equipped with a Taylor stoker of the three-retort type, and all but one have ignition arches. The exception apparently steams harder, but there has been no noticeable difference in the economy. Farmington, W. Va., coal having 13,800 B.t.u. and costing $2.75 per ton, is the fuel burned. A fuel bed averaging 30 in. is carried, and forced draft is supplied by either of two 60-hp. motor-driven fans with a capacity of 36,000 cu.ft. of air per min. At the wind boxes of the stoker the air pressure is 3 in. of water.

The breeching is rectangular in section, at the farthest boiler the dimensions being 4 ft. 4 in. by 4 ft., at the second boiler, 4 ft. 1 in. by 6 ft. 5 in., and at the fourth boiler and from there on to the stack, 4 ft. 4 in. by 9 ft. 6 in. Three sweeping turns intervene between the boilers and the stack, but as the latter rises 370 ft. above the grates and gives a theoretical draft of nearly 2.5 in. at 500 deg., the added resistance to the flow of gases is easily cared for. As a matter of fact, it is necessary to damper the pull of the stack to a small fraction of an inch over the fire, as the blower forces the air through the fuel bed and it is only necessary for the stack to overcome the resistance to the flow of gas in the settings and breeching. The stack is oval in section.

measuring 4 ft. 10 in. by 9 ft., and is lined all the way up with 2½-in. vitrified asbestos. The entire load is now carried by one boiler which, during the winter, is run at 40 per cent. overload, in the spring and fall at rating, and in the summer it is underloaded.

Feed water is drawn from a 1500-hp. open heater by either of two outside end packed plunger pot-valve pumps, 7½ and 5 by 10 in., which have duplicate steam lines, one from each header. The water lines are also in duplicate. Two 2-in. injectors are installed as a reserve. The water is measured by a venturi meter and there is a second meter to measure the drips which are returned by means of a Holly system.

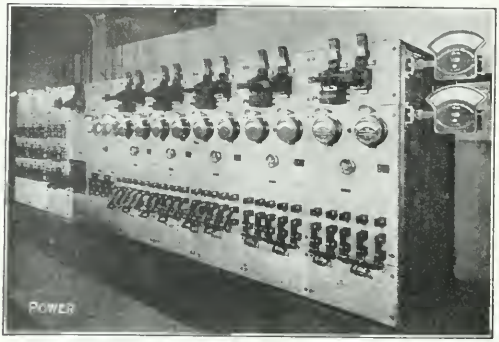


FIG. 4. TEN-PANEL SWITCHBOARD

COAL AND ASH HANDLING

Coal is delivered by wagon and dumped directly into a bunker 9 ft. 2 in. wide, 56 ft. long and 32 ft. deep. There are three manholes and four doors on the boiler-room side of the bunker near the bottom, the latter being equipped with gates and short chutes through which the coal is loaded into a traveling monorail bucket of 900-lb. capacity, fitted with a suspended type of scale. The bucket may be raised or lowered by an electric hoist. The stoker hoppers have been enlarged to hold four buckets of coal about 3600 lb., at a time, and at the outer edge have hooks which catch the bucket and cause it to tilt its contents into the hopper.

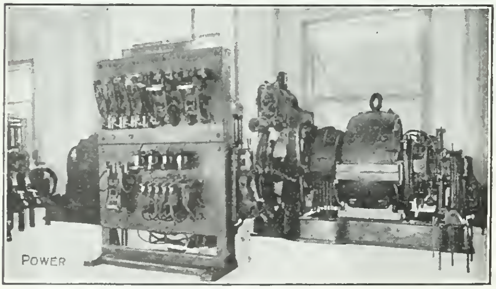


FIG. 5. ELEVATOR MOTOR AND CONTROL BOARD

For removing ashes the same bucket is lowered into the ashpit which extends past the boiler front. The ashes are shoveled in and then carried to a bucket elevator at the end of the boiler room.

ENGINE ROOM

There are five generating units rated at 200 kw. The engines are 17x27-in. and of the four-valve, nonreleasing type provided with 10-ton flywheels and revolving at 150 r.p.m. Fig. 3, shows one of the units. The generators are three-wire, 115-230-volt direct-connected machines and designed to adjust an unbalancing of 200 amp. per side. The engine cylinders are oiled by force-feed lubricators. Oil from the bearings is passed through filters once a week and returned to the four-barrel storage tank near the engine-room ceiling to give a gravity flow to the bearings.

The switchboard, Fig. 4, has ten panels of blue Vermont marble, five for generators, one tie panel, and four feeder panels. There are two sets of busbars, one for power and one for light, and when necessary the two can be thrown together at the tie panel. Two integrating meters record the lighting load, one the total output and another the supply to the elevators. There is also a gage board showing pressures on the various boilers and headers, the city water and heating mains and the air compressor. On the steam services there are also recording gages, and a differential draft gage shows the pressure in the breeching.

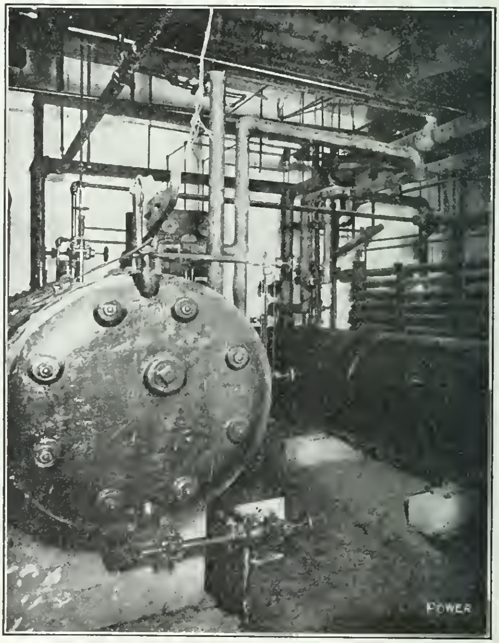


FIG. 6. PART OF THE ABSORPTION PLANT

PIPING

As shown in the plan of the piping, Fig. 7, 8-in. leads extend from the middle drum of each boiler through automatic stop and non-return valves to a 12-in. steel header. Horizontal bends of 7-ft. radius care for the expansion and contraction. The header has a valve at the center and one at either end, so that any one of the boilers may feed in either direction, an 8-in. loop making the circuit of the engine room. Six-inch pipes supply

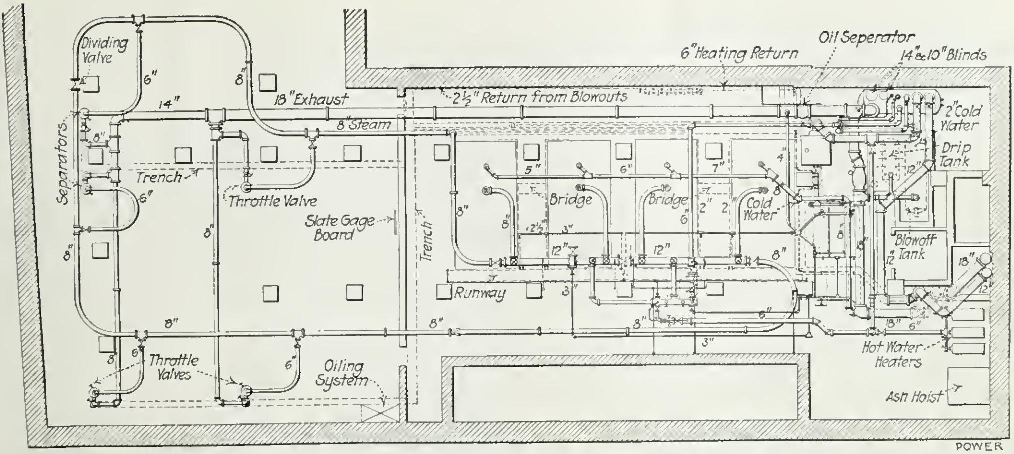


FIG. 7. PLAN OF PIPING IN ENGINE AND BOILER ROOMS

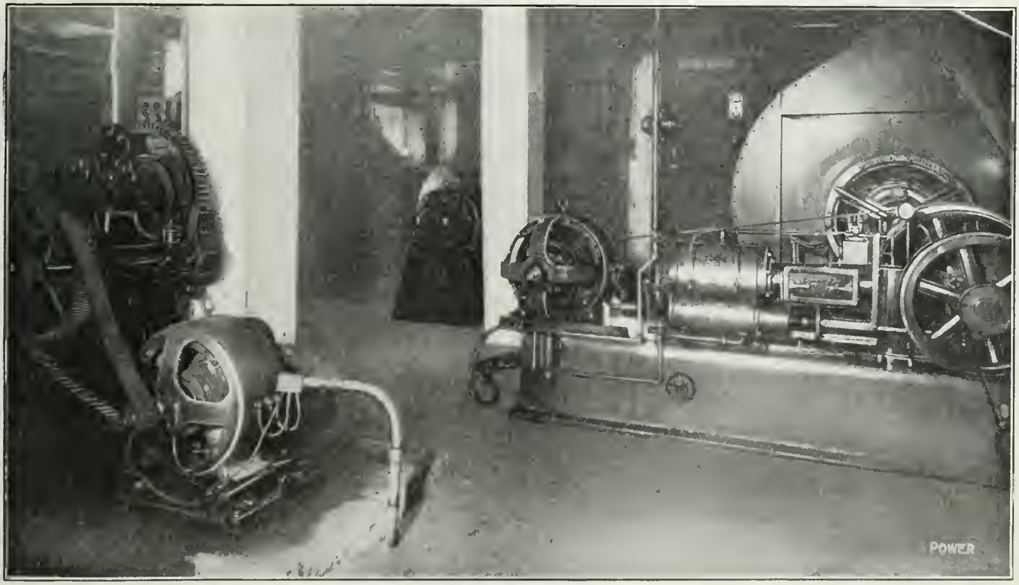


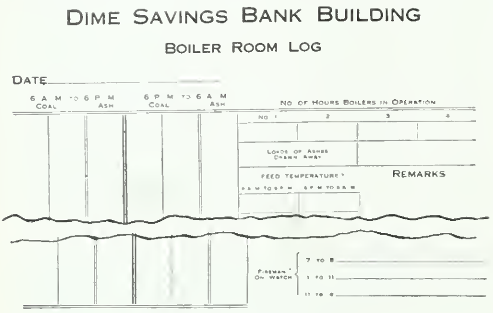
FIG. 8. VULCAN CLEANER AND ONE OF THE POWER PUMPS

each unit. Feeding three engines fully loaded and taking 40 lb. of steam per kilowatt-hour from one end of the header demand a steam velocity of 3200 ft. per min. in the loop and 1800 ft. in the engine-supply pipes. The loop is made up of extra-heavy steel pipe with vanstone joints and a valve at the center dividing the units two and three.

The exhaust pipes from each engine are 8 in. in diameter and under the conditions given for the supply with the discharge at atmospheric pressure and a quality of 87 per cent., necessitate a steam velocity of nearly 9000 ft. per min. This appears a trifle high and, on the contrary, the velocity of the supply is below the average. The exhaust pipes unite into a common 18-in. exhaust main discharging into a 5x10-ft. expansion tank or through a back-pressure valve to atmosphere. From the expansion tank one 12-in. pipe supplies the feed-water heater and three hot-water heaters for house service with exhaust steam. Another 12-in. pipe for direct heating rises to a pipe gallery above the twenty-third floor and feeds downward through 44 branches. From the same number of return lines the condensation from the heating surface is collected in a 6-in. header and returned to the heater by either of two 10 and 16 by 16-in vacuum pumps. The smaller taps to the expansion tank go to the indirect surface, and it will be noticed that there are two 10- and 14-in. blank flanges, one for the Ford Building and one for future use. A 6-in. pipe from the auxiliary boiler header supplies the expansion tank with live steam when necessary and a second pipe of the same diameter carries live steam to the feed and hot-water heaters, each of the latter having a capacity of 1400 gal. per hour. The low-pressure drips are collected in a drip tank and trapped to the sewer.

Miscellaneous Pumps and Fans

To indicate which of the auxiliaries are power driven and which steam, the following is a list of pumps and fans not previously mentioned. There are one $5\frac{1}{2}$x8-in. triplex house pump driven by a 15-hp. motor, and one $2\frac{1}{2}$-in. centrifugal for the same service. For the 30-ton absorption system there are two $6\frac{1}{8}$ and 4 by 8-in. simplex pumps to circulate the drinking water, two 10 and $6\frac{1}{2}$ by 12-in. pumps to circulate the brine to the restaurant and one aqua pump, 8 and $3\frac{1}{2}$ by 12-in. There are also two motor-driven 4-in. centrifugal sump pumps and one 12 and $6\frac{1}{2}$ by 12-in. elevator pump serving a hydraulic money lift, and a hydraulic elevator running between the first floor and the safety deposit vaults of the bank.



DIME SAVINGS BANK BUILDING

BOILER ROOM LOG

DATE

6 A M to 6 P M COAL	 ASH	6 P M to 6 A M COAL	 ASH

NO OF HOURS BOILERS IN OPERATION

NO 1	2	3	4

LOADS OF ASHES DRAWN AWAY

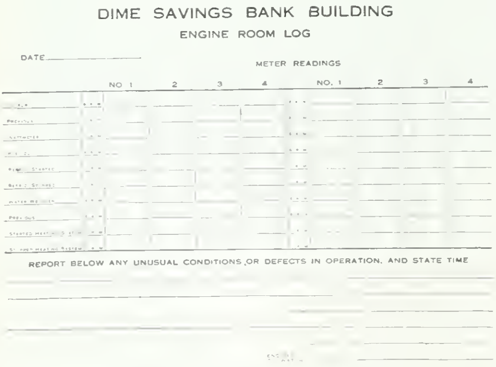
FEED TEMPERATURE °

6 A M TO 6 P M	6 P M TO 6 A M

REMARKS

FIREMAN ON WATCH
7 TO 3
3 TO 11
11 TO 7

FIG. 9. BOILER-ROOM LOG



DIME SAVINGS BANK BUILDING

ENGINE ROOM LOG

DATE

METER READINGS

	NO 1	2	3	4	NO. 1	2	3	4

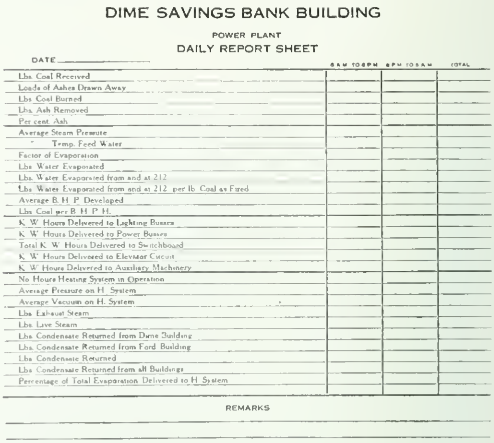
REPORT BELOW ANY UNUSUAL CONDITIONS OR DEFECTS IN OPERATION, AND STATE TIME

FIG. 10. ENGINE-ROOM LOG

For blowing the motors and generators, for hot-water-heater control and in the barber shop, compressed air at 20 to 25 lb. pressure is required. This is supplied by two small compressors driven by 3-hp. motors. The vacuum cleaner requires a 15-hp. motor and the two air washers for the bank and restaurant have $1\frac{1}{4}$-in. pumps driven by 3-hp. motors. In the basement there are five fresh-air fans requiring a total of 40 hp. in motors and four exhaust fans taking 22 hp.

Records

With the meters and gages previously mentioned steam-flow meters soon to be installed on the outlet of each boiler, a CO_2 apparatus and a water weigher on the heating system, the facilities are good for the excellent system of keeping records shown herewith. Fig. 9 is the boiler-room log, Fig. 10 the engine-room log, and Fig. 11 the power-plant daily report sheet. From this sheet the monthly report is plotted on coördinate paper which is hung in a double roll on the wall, the records for the past month being rolled up as fresh paper for the current records is unrolled. The records for the entire year are eventually available on the roll.



DIME SAVINGS BANK BUILDING

POWER PLANT

DAILY REPORT SHEET

DATE

	6 A M TO 6 P M	6 P M TO 6 A M	TOTAL
Lbs. Coal Received			
Loads of Ashes Drawn Away			
Lbs. Coal Burned			
Lbs. Ash Removed			
Per cent. Ash			
Average Steam Pressure			
" Temp. Feed Water			
Factor of Evaporation			
Lbs. Water Evaporated			
Lbs. Water Evaporated from and at 212			
Lbs. Water Evaporated from and at 212 per lb. Coal as Fired			
Average B. H. P. Developed			
Lbs. Coal per B. H. P. H.			
K. W. Hours Delivered to Lighting Busses			
K. W. Hours Delivered to Power Busses			
Total K. W. Hours Delivered to Switchboard			
K. W. Hours Delivered to Elevator Circuit			
K. W. Hours Delivered to Auxiliary Machinery			
No. Hours Heating System in Operation			
Average Pressure on H. System			
Average Vacuum on H. System			
Lbs. Exhaust Steam			
Lbs. Live Steam			
Lbs. Condensate Returned from Dime Building			
Lbs. Condensate Returned from Ford Building			
Lbs. Condensate Returned			
Lbs. Condensate Returned from all Buildings			
Percentage of Total Evaporation Delivered to H. System			

REMARKS

FIG. 11. POWER-PLANT DAILY REPORT SHEET

Albert Kern is manager of the Ford properties and V. L. Bowles is chief engineer of the plant. To the latter we are indebted for much of the information contained in this article.

⁂

Balancing of Machinery—In these days of high rotational speed, the whole question of the balancing of machinery has assumed redoubled importance, for, if there is any lack of proper balancing, the ensuing vibration will in magnitude be proportional to the square of the speed, while the number of times the vibrational force is applied per minute will vary directly as the speed. Thus, if we consider only fatigue stresses, the harmful effect of a given amount of lack of balance would increase as the third power of the speed of rotation.—"The Engineer."

⁂

Boiler Failed in Capacity—One of two 250-hp. boilers failed to develop its rated capacity. There being no flue-gas analyzing outfit handy, the plant manager arranged to determine the performance of all the boilers. A small hole was drilled in the rear wall of the boiler setting just below the line of lower tubes, and a small iron rod was inserted a short distance under the boiler. With the highest rate of combustion, the rod would melt at the end; with fairly good combustion, the rod became white hot; with excess air coming through the grate and a large percentage of the gas passing up the stack, the rod remained black or red. Because of these tests one boiler was discontinued, resulting in a saving of approximately one pound of coal per kilowatt-hour.

Effect of Speed upon Direct-Current Generators

By Gordon Fox

SYNOPSIS—Explanation and curves showing how a change in speed will affect the voltage regulation and the commutation due to increased armature reaction.

⁂

Not infrequently, direct-current generators are driven at speeds differing to some extent from those for which they are rated, and it is interesting to note the effect of such changes upon the operating characteristics. Two results may be more or less pronounced: First, the compounding or voltage regulation of the machine is changed, and, second, the commutation may be affected and a different neutral or best-running brush position occur.

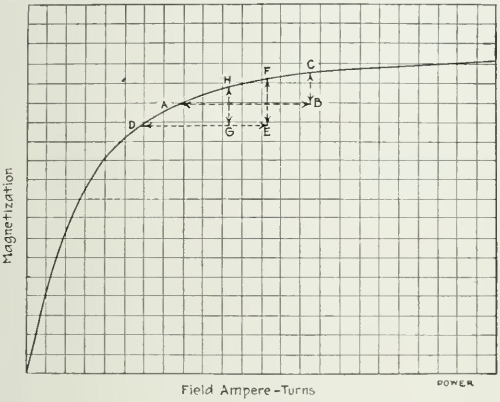


Fig. 1. Saturation Curve

The effect of speed upon compounding is shown in Fig. 1, which is a saturation curve for the magnetic circuit of a direct-current generator, operating normally at 250 r.p.m. The 220-volt no-load point occurs at *A*, just above the knee of the curve, and the ampere-turns due to the series field are represented by *AB*. The increase in magnetic density caused by these additional ampere-turns in the field is shown by *BC*. This additional excitation causes an increase of 25 volts in terminal pressure between no load and full load at 250 r.p.m.

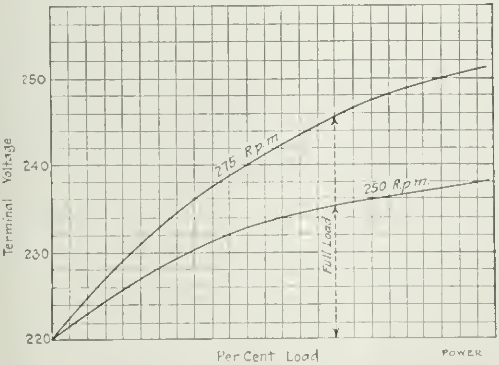


Fig. 2. Regulation Curves at Different Speeds

If this generator be speeded up to 275 r.p.m., it will operate over a different portion of the magnetization curve. Due to the increase in speed, the no-load voltage, 220 volts, will be delivered at a lower degree of saturation. This point will then occur at a lower portion of the curve, at *D*. The series field, still having the same ampere-turns with the same load, represented by *DE*, will have a magnetizing effect, *EF*. This increase in magnetization, due to the series field ampere-turns, is seen to be greater than before, the distance *EF* being greater than *BC*. Moreover, an equal increase in magnetic density will cause a greater increase in voltage at 275 than at 250 r.p.m.

The two regulation curves are shown in Fig. 2. The curve for the machine operating at 250 r.p.m. is similar to the portion of the magnetization curve from *A* to *C*. Internal-resistance drop and armature reaction tend to cause the voltage to decrease with the load, whereas the increase in terminal voltage due to over-compounding causes the effect of the shunt field to increase, largely counteracting these tendencies. The curve for the machine operating at 275 r.p.m. is obtained by increasing each value of compounding effect, such as *GH* and *EF*, by the ratio 275/250. These values are not entirely correct, due to the factors noted above, but are close approximations for comparison.

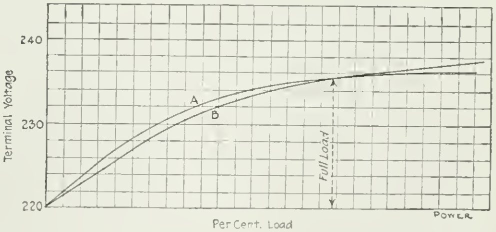


Fig. 3. Regulation of Two Equally Compounded Dynamos with Different Characteristics at Intermediate Points

It will be seen that a change in speed of a direct-current generator will cause a considerable change in its compounding characteristics. Machines operating above speed will usually require a german-silver shunt around the series field to maintain the over-compounding at the desired value.

The portion of the magnetization curve over which a generator operates may have an important effect when two machines are paralleled. Fig. 3 shows the voltage regulation curves of two generators equally over-compounded in that the rise in voltage from no load to full load is the same for both. At intermediate loads, such as half load, there is considerable difference in voltage, so that if the machines be connected in parallel, machine *A* will tend to take the greater share of the load at this point. This makes it apparent that a correct division of load cannot be maintained over the entire operating range if the two or more generators in parallel have dissimilar regulation curves. As previously stated, the shape of the regulation curve depends largely upon that portion of the magnetization curve over which a machine operates. It was shown that a change in speed will change the operating point on the magnetization curve, hence it is evident that it is generally possible by adjusting prime-mover speeds slightly to modify the compounding curves in such a manner as to improve the load division by causing the machines to have similar voltage regulation characteristics.

The second effect of speed change is in respect to commutation. If a machine be driven above normal speed it will deliver rated voltage at a lower degree of magnetization than normal. If the iron be thus less saturated, the effects of armature reaction will be more pronounced, the neutral more widely shifted with load changes and sparking more likely to take place. The full-load neutral will probably occur at a different point than that for normal operation, so that a relocation of the brushes will be desirable.

Advantage of this feature may be taken in an opposite manner. If a generator operating at normal speed shows a tendency to sparking and it is found that the neutral point shifts widely with the load, indicating a strong armature reaction effect, then it may be possible to remedy, or at least to alleviate, the difficulty by slowing down the drive a little. This will cause the generator to operate at a higher degree of saturation in order to deliver its rated voltage. Operating at the higher magnetic density, the neutral will be more stable and commutation should be improved. This has the effect of increasing the relative field ampere-turns with respect to armature ampere-turns, a change productive of better commutation constants.

Centrifugal-Fan Characteristics

By Frank L. Busey*

SYNOPSIS—The performance of a fan depends largely upon its intelligent selection to meet the operating conditions. When to choose a multi-vane and a straight-blade fan. Static and total efficiencies are also defined.

* * *

The centrifugal fan is meeting with increasing application in general engineering practice, yet little attention has been paid by the majority of engineers to the advancement in design and construction of fans, or to the performance and selection of the various types. The electrical engineer now uses fans for generator cooling; the power-plant engineer for forced and induced draft as well as for the removal of ashes and the cooling of hot boiler rooms; and the operating engineer in industrial or public-building installations uses fans for heating, ventilating and cooling. The fan also has many special applications in various industries, such as furnishing blast to forges and furnaces; the removal of industrial waste by means of exhaust systems and the supplying of air for various drying and manufacturing processes.

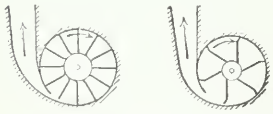


FIG. 1
THE GUIBAL FAN AND CHIMNEY

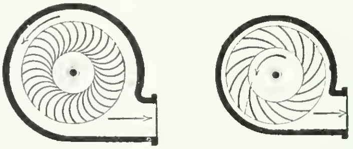


FIG. 2
D'ANTHONAY FAN FARCOT FAN

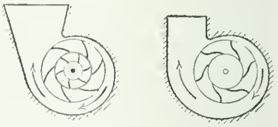


FIG. 3
THE CAPELL FAN THE RANKINE FAN

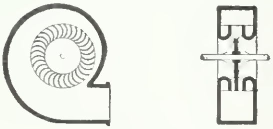


FIG. 4
THE SER FAN

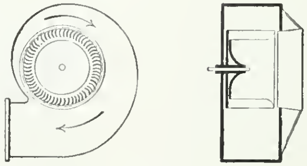


FIG. 5
THE DAVIDSON FAN

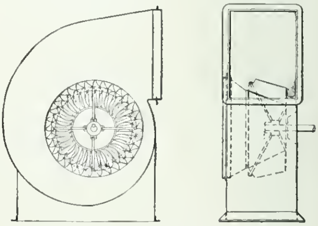


FIG. 6
NIAGARA CONOIDAL FAN

POWER

Different Types of Fans

The term "centrifugal fan" designates that form of construction commonly known as the steel plate or multiblade type as distinguished from the positive blower type, such as the Root or Connersville. It is used to work against comparatively low pressures, ordinarily only a few ounces, or at most about 16 oz., and is made up of a rotating arbor or plate to which are attached a series of blades. When this drum is rotated, the columns of air between the blades are given a centrifugal motion, delivering the air from the center to the wheel circumference.

In different forms, the centrifugal fan has been built for over 200 years, and even as far back as 1847 a Mr. Buckle presented data before the Institute of Mechanical

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*Deceased.

Engineers for the design of fans which does not differ greatly from present practice. In 1872 the first complete treatise on the theory of the centrifugal fan was published by Daniel Murgue, engineer to the Colliery Company of Besseges, and this theory is still accepted by authorities on fan performance. These earlier fans were used largely for mine ventilation, and later for the ventilation of tunnels. At first they were simply for exhausting and were not fitted with a housing. In this way only the centrifugal velocity was employed, and no benefit was derived from the rotational velocity.

Some of the earliest fans are shown by Figs. 1 to 3, from which it will be noticed that some were fitted with a cone-shaped discharge, intended to reduce the velocity of the air. This same principle is still used in fans for mine ventilation. The earliest fans were built both with straight and with curved blades, but these blades were always long radially, and in some cases the housing was circular instead of spiral in shape; therefore, no benefit was obtained from the centrifugal action of the air within the fan wheel, and only the velocity of discharge was utilized.

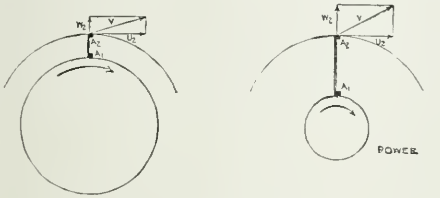

Fig. 7. Effect of Centrifugal Action in Fan Wheels

One of the first multivane types using short curved blades was designed by Professor Ser, of Paris, about 1884, a sketch of which is shown in Fig. 4. Numerous other designs of curved-blade multivane fans were patented within the next 15 years, but the most widely known is the Davidson patent, more commonly called the Sirocco fan, shown in Fig. 5, which represents the fan as first patented, in 1900. Various American fan builders have brought out multivane fans within the last few years, generally differing in some essential feature from the Sirocco fan.

One of these is the Niagara Conoidal fan, Fig. 6, which embodies two special features: First, the diverging cone effect is brought back into the fan housing, giving an actual lower outlet velocity and a consequent higher static pressure; secondly, the wheel is different in its design from anything previously built. The blades are of greater depth radially at the back than at the front, and are generated on a cone by a generatrix not parallel to the axis. By making the tangential velocity less at the back of the wheel than at the front, the difference in centrifugal velocity is so balanced as to give an even pressure across the entire tip edge of the blade.

Relative Performance of Straight- and Curved-Blade Types

In any centrifugal fan there are two separate and independent sources of pressure: First, the centrifugal force due to the rotation of the air within the wheel; second, the kinetic energy contained in the air by virtue of its velocity upon leaving the periphery of the fan rotor. The action of the centrifugal force upon the particles of air within the fan wheel may be illustrated by the two diagrams in Fig. 7. Due to the centrifugal force, a particle of air at A, at the heel of the blade, will be thrown to the tip and given a velocity W_2. The resulting velocity V is the combined effect of W_2 and the rotational velocity U_2. From a comparison of these two figures it is evident that a fan with longer blades, if they are both straight, will give a greater pressure than may be obtained from a short-bladed fan at the same speed.

By curving these short blades either forward or backward, as in Fig. 8, any desired variation in velocity may be obtained for the air leaving the tip of the blade. Thus when the blade is bent forward, a pressure greater than that corresponding to the peripheral velocity will be obtained. This results in the same pressure at a lower speed than would be necessary with a straight blade and the same wheel diameter. In case it is desired to directly connect a fan to a high-speed unit without developing the corresponding high velocity, the blade may be bent backward.

Centrifugal fans may be divided roughly into two classes, those with straight radial blades and those with blades curved with reference to their direction of rotation. The amount of total pressure developed by a straight-blade fan may be mathematically determined, but in the case of a curved-blade fan this can be known only by actual test.

An essential feature is the housing in which the wheel or rotor is inclosed. The kinetic energy of the air leaving the periphery of the wheel to a great extent must be converted into potential energy in the form of static pressure before being serviceable. This conversion from kinetic energy or velocity into static pressure is ordinarily accomplished in the scroll formation of the fan housing. A still further conversion is often secured, where the velocity leaving the outlet is high, by means of a diverging nozzle at the outlet. The shorter the blade, the greater must be the dependence on the scroll-shaped housing to obtain the desired static pressure, and for this reason a properly designed housing is of more importance with a multivane fan than with the older straight-blade type.

The standard steel-plate fan may be considered as a specimen of the straight-blade type, although if the tip of the blade is bent in either direction, the characteristics will be slightly changed. The ordinary steel-plate fan does not give as high an efficiency as the multivane type, because it is designed for large capacity rather than for high efficiency. But if these straight-blade fans are made long and narrow, with a smaller inlet than is used on the standard fan, they may be made to give higher efficiencies than can be obtained from any of the multivane type of fans.

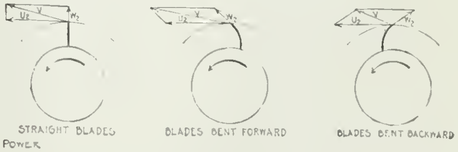

Fig. 8. Relative Effect of Different-Shaped Blades

The size of inlet depends on the cubic feet of air handled per revolution of the fan, and there is a certain diameter of inlet that will give maximum economy. The smaller the inlet diameter as compared to that of the wheel, the greater will be the efficiency obtained, but at a sacrifice in capacity.

Relation between Static, Velocity and Total Pressures and between Static and Total Efficiency

Frequent reference has been made to static and velocity pressures, and also to the conversion from velocity pressure to static pressure at the fan outlet. In practically all installations using centrifugal fans there exists a certain static resistance of the system to be overcome. One common source of such resistance is the loss by friction due to transmitting the air through a system of ducts, which varies with the roughness of the surface, the resistance of elbows or other obstructions, and as the square of the air velocity. A further source is in the fuel bed of furnaces or the grates of a boiler; the resistance offered by the boiler itself or by an economizer in the case of an induced-draft fan; the loss in head at the hoods and through the collector in an exhaust system; and the resistance of the heating coils or air washer in a heating or ventilating installation.

It is necessary for the fan to develop a definite static pressure sufficient to overcome the various static resistances of the system. In addition to the static pressure, the air has imparted to it a certain velocity pressure due to its velocity on leaving the fan outlet. This velocity is dependent on the amount of air handled and on the area of the fan outlet.

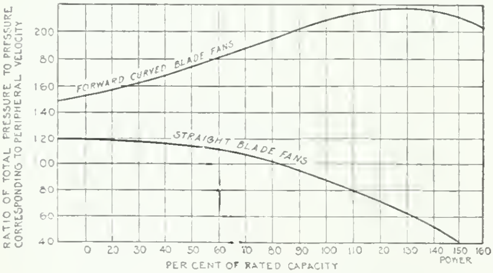

Fig. 9. Pressure Characteristics at Constant Speeds

The total pressure is the velocity pressure at the fan outlet plus the static pressure of the system, and is the pressure upon which the performance and efficiency are usually based. In the case of an exhaust or "draw-through" system, the static head should be taken as the difference in static pressure at the inlet and outlet of the fan, one being positive and the other negative.

The relation between static and total pressure and between static and total efficiency is not generally understood. Many consider only the total efficiency, even when the resistances are estimated in static pressures. The static pressure is the potential energy developed by the fan, and is the energy available for performing useful work in overcoming the frictional resistance of the system. The velocity pressure is the kinetic energy used in moving the air and is a measure of the air quantity handled, but until it is converted to static pressure it is not available for overcoming resistance.

Thus it is seen that the greater the static pressure developed at the fan outlet in proportion to the velocity pressure, the more effective will be the performance of the fan in overcoming frictional resistance, and therefore the greater the "static efficiency." The efficiency is the ratio of the power output to the power input, or the ratio of work done in delivering a certain amount of air against some known pressure to the work done by the engine or motor used in driving the fan. There may be two different efficiencies, static or total, depending on whether static or total pressures are considered. Since the total pressure is greater than the static, the total efficiency is greater than the static efficiency, and for this reason the efficiency generally referred to in fan performance is based on the total pressure.

A fan having a high total but a low static efficiency may be less desirable than another having a high static efficiency but relatively lower total efficiency. The static efficiency may be readily calculated when the ratio of static to total pressure at the rated capacity of a fan is known. Thus, if the static pressure is 80 per cent. of the rated total pressure, the static efficiency will be 80 per cent. of the total efficiency.

The efficiency, in terms of either the static or total pressure, may be calculated by means of the following formulas:

$$\textit{static efficiency} = \frac{0.0001565 \times Q \times \textit{static press. (inches)}}{\textit{horsepower input}}$$

$$\textit{total efficiency} = \frac{0.0001565 \times Q \times \textit{total press. (inches)}}{\textit{horsepower input}}$$

where Q equals the quantity of air in cubic feet per minute.

Relative Pressure Characteristics of Steel-Plate and Multivane Fans

As may be seen from Fig. 9, the pressure characteristics of a fan having forwardly curved blades are quite different from one having straight blades. This is not generally understood and is often overlooked in the selection of a fan for any specific duty. It will be noted from the curves that when a fan with forwardly curved blades is operated at constant speed and at less than the rated capacity corresponding to that speed, the total pressure developed will be less than the rated pressure at rated capacity. Given this same condition with a straight-blade fan, operating at constant speed, the pressure tends to increase as the load on the fan is reduced.

These relationships are frequently of great importance in the selection of a fan, and numerous disappointments in performance may be traced to the fact that the fan was not adapted to the conditions under which it was to operate. Thus if a fan be used to supply forced draft to a boiler, when an additional load comes on and an extra supply of coal is added to the fire, an increase in pressure should be available to overcome the extra resistance of this fresh fuel and keep up the rate of combustion. It will be noted from Fig. 9 that unless the fan speed is increased, a multivane fan under these conditions will give a decreasing pressure. Owing to the thickening of the fuel bed, the delivery of the air is throttled, and as the capacity of this type of fan is decreased below the rated point, the total pressure falls off. Just the opposite will hold true of a straight-blade fan. On the other hand, if a fan is to be operated at considerable overload without an increase in speed, the pressure of the straight-blade fan will fall off, but the total pressure of a forwardly curved multivane type of fan will increase.

A better conception of the relative performance of the two types may be had from a comparison of the diagrams in Figs. 10 and 11. The curves in Fig. 10 show the relative performance of a straight-blade steel-plate blower of standard make, and gives the performance at other than the rated capacity. The horsepower characteristics for this type give a straight line. According to the curve, the rated total efficiency for this fan is 50 per cent.

The curves in Fig. 11 show the relative performance of a well known fan of the forwardly curved blade multivane type. If this fan is operated at 50 per cent. of the rated capacity but at rated speed, the static pressure will be about 83 per cent. only of the rated and there will be a drop in static efficiency of approximately 10 per cent. One advantage of this type may be noted from Fig. 11, where it will be seen that the static pressure curve is comparatively flat at the point of rating, and that a considerable range of capacity may be obtained without serious loss in efficiency. Also, as seen from the horsepower curve beyond the point of rating, the power consumption goes up very rapidly, with an increasing total pressure. This explains why this type, when motor-driven, is so likely to overload the motor and why care should be taken to specify a motor sufficiently large if there is any possibility of an excessive overload.

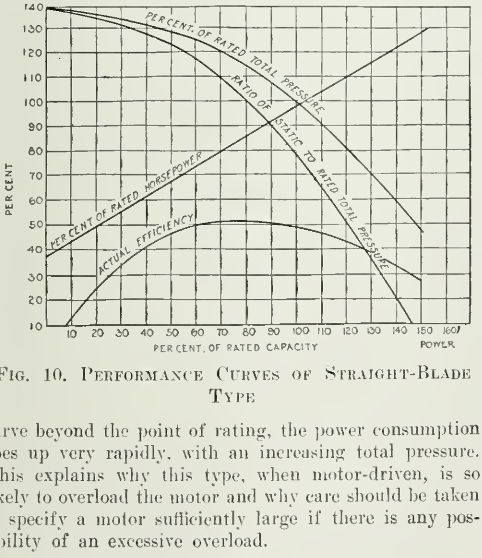

Fig. 10. Performance Curves of Straight-Blade Type

Conclusions

From the foregoing it will be seen that different types of fans have widely different characteristics, and should be intelligently chosen if the best results are to be expected. While the impression seems quite general among engineers that the multivane fan is inherently more efficient than the steel-plate type, this is true only of the commercial steel-plate fans as ordinarily placed on the market. These fans are designed for large capacity rather than for high efficiency, but if properly designed, a straight-blade steel-plate fan may be made to give even higher efficiencies than multivane fans. This calls for a tall, narrow fan.

The multivane fan is of special advantage where space (more particularly head room) is of importance. Its higher speeds are also an advantage, since they allow direct connection to higher-speed motors, or give better pulley ratios where the fan is belt driven. Where a constant or increasing pressure is required when operating at less than the rated capacity, the straight-blade fan should be used, but the multivane type is the better one to use where a constant or increasing pressure is required above capacity.

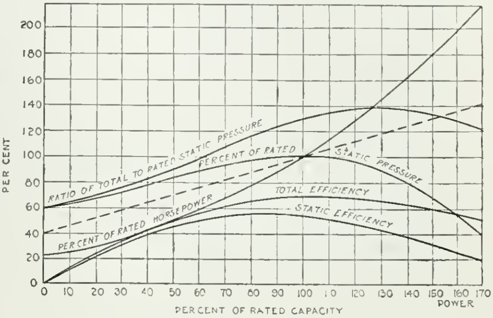

Fig. 11. Performance Curves of Curved-Blade Type

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Formula for Self-Supporting Steel Stacks

By W. S. Durand

Steel chimneys are coming more and more into favor, especially where ground space is limited or the stack is erected over the boiler and the area occupied by the boiler has to be incorporated with that required for the chimney. Steel stacks also have the advantage of being easily and quickly constructed, have less weight for a given diameter and height and have less surface exposed to the wind; they also cost much less than other types of chimneys. The main disadvantage seems to be that the upkeep cost is greater since a steel stack must be kept well painted to prevent corrosion.

In most cases, steel chimneys are self-supporting and are generally made with a bell-shaped base 1½ to 2 times the diameter of the stack. This is riveted to a heavy cast-iron plate bolted to the foundation. The steel is thickest at the bottom and decreases toward the top of the stack. The proper thickness for any given section may be determined by treating the shaft as a uniformly loaded cantilever, the wind being ordinarily the only force tending to overturn the stack since it is rigidly bolted to the foundation

Without going into the necessary steps leading to the solution of this problem, the equation of moments may be reduced to the final form:

$$Ph = S\frac{\pi}{32}\left(\frac{D_1^4 - D_2^4}{D_1}\right)$$

Where

P = Total wind pressure in pounds;

h = Distance from center of wind pressure down to a given point for which the thickness is to be determined;

S = Safe stress in pounds per square inch of material;

D_1 = External diameter of the shell in inches;

D_2 = Internal diameter of the shell in inches.

This is the usual formula appearing in most books on the subject, but it is rather complicated and requires considerable time for its solution. By using different notation and a slightly modified form for the moment of inertia, the formula for thickness may be expressed as,

$$t = \frac{Ph^2}{\pi Sr}$$

Where

t = Thickness of shell in inches;
P = Wind pressure in pounds per square foot;
h = Distance from top to the section under consideration, in feet;
S = Safe stress in pounds per square inch;
r = Half diameter in inches.

Single-riveted joints are ordinarly used on stacks, but where great stiffness is desired all girth seams are double riveted. Allowing 6000 lb. per sq.in. as a safe stress for single-riveted joints, 8000 lb. for double-riveted joints and a maximum wind pressure of 25 lb. per sq.in., this formula, for all practical purposes, may be considered as reducing to the following simple forms:

For single-riveted girth joints,

$$t = \frac{h^2}{750\,r}$$

For double-riveted girth joints,

$$t = \frac{h^2}{1000\,r}$$

The least thickness that should be used is $\frac{3}{16}$ in., and where the stack is over 7 ft. in diameter, or 150 ft. high, the thickness should not be less than ¼ in.

Oils and Lubrication--II

By L. D. Allen

As the writer has never found laboratory tests of much practical value in the selection of oils, greases and babbitt metals, he has of necessity confined his remarks to that which he has observed and has been told in exchanging experiences with engineers and machinists on the firing line who had to do with the use of these commodities in a practical way. The distrust of testing-machine results is due to the fact that testing-machine journals are as perfect as care and the machinist's skill can make them, whereas in actual mill, factory and shop use they are not only less perfect, but are subject to all sorts of varying conditions, and more particularly the conditions indigent to each plant. Even the oiling devices are entirely different. The bearings of the testing machine may be made of babbitt, while the oil that showed up so beautifully on these babbitted bearings may be used in bronze or brass bearings and the slight proportion of free acid in the oil or grease, as the case may be, which had no effect on the babbitt, will at once start corrosion on the surface of the bronze or brass.

The laboratory may contribute much toward showing to what extent an oil or grease has been doped with deteriorating products, but when the extent of its adulteration escapes detection in many of the ordinary tests then the quality is affected hardly enough to make any noticeable difference in its lubricating value for general bearing requirements. This little difference, however, existing in each bearing throughout a large mill, factory or plant, foots up a considerable item, and, as an engineer suggested, the answer to the question of oil economy is whether more or less power is required. The oil, grease or babbitt may seem to be doing all right, but what is it costing at the power end?

Oil, like water, when heated by friction, evaporates, passes off like steam and is lost into space with the heat it has absorbed. This transformation is said to take place at the point where the shaft rests heaviest in the bearing. The greasy appearance of the face when one has spent a day in an engine room shows how thoroughly the air is charged with oil vapor.

With the new oils having greater viscosities and lower gravities, the specification and simple test methods that have prevailed for years must be confined to oils produced from the same crudes.

Pennsylvania and Southwestern Crudes

The oils from the Western and Southwestern crudes are now being sold on factory results; the Pennsylvania or paraffin-base oils are still being handled on the old specification basis. For those who are using the Pennsylvania oils the following will be of interest.

Up to recent times, the Pennsylvania crudes have had the reputation of giving oils that make the best light-spindle lubricant, and oils that stand the highest temperatures for automobile service, while the California, Texas and some Western crudes produce the heavier hydrocarbons that possess the body best for general machinery lubrication where there are great stress and heavy loads.

From recent scientific tests made on internal-combustion engines it has been proved that those oils which have been refined from low-gravity crudes—the Texas and California crudes—show in the combustion chamber a carbon formation of a softer nature than oils refined from a paraffin-base crude, an obviously desirable feature.

The red oils represent the stocks used in general machinery lubrication; the light brown, lemon and pale lemon are the oils used in high-speed engine, motor and automobile service, grading to the extra pale and water-white oils used in spindle-bearing, sewing-machine and clock lubrication and places where stainless oils are required. The Southwestern crudes produce the higher viscosity oils without the aid of admixtures. These may run in color from red oil to lemon; the same is true of the paraffin-base oils. It is a known fact that for steam-cylinder lubrication it is necessary to use a cylinder stock refined from a paraffin-base crude. This may be Pennsylvania, Ohio, Indiana, Illinois or Oklahoma crude, all of which give equal results if the stocks are carefully selected to meet the operating conditions. The dark steam-refined stock is most generally used as it has a high flash test and shows greater viscosity. Being a petroleum product, however, it has no affinity for moisture. It will not stick to wet cylinder and valve surfaces, and must, before it is a good steam lubricant, be compounded with a certain amount of fatty oil, usually tallow, so that it will emulsify and cling to the surfaces.

Engine-Room Tests

Following are some of the common engine-room tests for ascertaining quality and uniformity that have been quite generally used with Pennsylvania lubricants:

For gummy conditions, spread the oil on a glass plate and expose it to dry heat. The sticky nature of the residuum, or what is left, indicates the extent of its gummy qualities.

To get an idea of the real lubricating body or viscosity of an oil, get two or three glass tubes of the same dimensions, fill them to the same extent and allow the oils to drop out of the small ends of the tubes. See which of the two or three oils drop the quickest. The most viscous oil will move or drop the slowest. By varying these tests at a cooler or warmer temperature, the evenness of the viscosity can be determined. The most practical temperature, of course, is that which corresponds with the general running temperature of the bearings in which the oil is to be used.

Another test for ascertaining the clinging qualities, as well as the viscosity of an oil, is to pour a drop of each of several oils at a slight distance from each other on a clean inclined glass plate, having the plate at about the temperature of the bearings, and notice the time it takes for each drop to reach the bottom. By changing the temperatures, the uniform consistency can be determined.

Place two oils side by side on clean blotting paper resting on a steam heater. The oil which evaporates the quickest and spreads the widest is the thinnest oil. It shows by its lightness that it is compounded with material of light specific gravity. If exposed for some time and all of the oil disappears, it shows that it is all petroleum. Pure petroleum penetrates the blotting paper faster than when compounded with fatty oils. When pure petroleum dries off, the translucency disappears. When a compound with fats drys, the blotter is permanently translucent. When an inner ring with a well defined form is noticeable, it indicates compounding with a light paraffin stock.

The specific gravity of an oil indicates its density or weight. This is easily determined by a hydrometer, which can be obtained at a trifling cost and requires no skill in its use. It should be thoroughly cleaned for each lot of oil tested. A combination hydrometer and thermometer is best.

Of all the tests, either laboratory or those just stated, the most essential test is to place a thermometer in contact with the bearing and determine the frictional temperature, that is, the temperature of the bearing minus the room temperature. The oil showing the lowest frictional temperature under like mechanical conditions is the best lubricant for that bearing.

For steam-cylinder lubrication the best practice is to check the cylinder-oil consumption for an hour's run. If possible, remove the cylinder head and determine the oil film by aid of tissue paper, noticing the number of sheets of paper penetrated by the oil film; this will give an idea of the extent of the lubrication being furnished. A good method is to use an ordinary stethoscope, which will enable the operator to distinguish the least groan or distress either in the cylinder or in the valves.

A lubricating oil should be free from sulphur compounds. A test to determine whether sulphur remains in the oil is to heat it to about 300 deg. F., maintaining the temperature for 15 min., then cool and compare the color with the original oil. If it is darker, it indicates that the oil has been badly refined. A great variety of bearing linings will not stand the corroding effects of sulphuric acid.

The flash point of an oil is that point in temperature at which enough vapor arises to ignite in the form of a flash over the surface when brought in contact with a flame. It is an important factor in determining the suitableness of oils that must stand high temperatures. In making the test, the flame should be brought only near enough to the oil to reach the vapor, say within ¼ in.

In textile mills and wherever the fire hazard has to be guarded against, special attention should be given to the flash point of the lubricant. Also, the flash point is an important item in the use of cylinder oils, as oils of high flash point evaporate less quickly.

The fire test shows the point at which the oil itself will ignite or burn, and is usually from 50 to 75 deg. higher than the flash temperature.

The cold test is the point at which the oil congeals. The most doubtful test is that concerning the viscosity of an oil because the viscosity may be due to the presence of wax or some form of adulterant. To the average layman, it is impossible to determine adulterations or, in other words, false viscosities except by noticing the differences in temperature on the same bearing. An adulterated oil will show greater frictional loss and naturally higher temperature.

Color is not a determining factor except in the case of selecting an oil for use on spindles where something is wanted that will not stain. The general machine oils are a ruby red and the motor and auto oils an amber or lemon color, varying in lightness and darkness according to their body or degree of refinement.

The gravities of oils are governed by the crudes from which they are made. The high-gravity oils are produced from the Pennsylvania crudes, while the Western or asphalt crudes show a lower gravity; the lower gravity indicates a greater carbon content.

Oils for Different Uses

A good all-round red oil for general lubrication made of Western or asphalt crudes will show 23 to 24 gravity, about 395 flash and 250 to 295 viscosity, while an oil used for the same purposes made from Pennsylvania crudes will show about 30½ gravity, with the other points about the same except the viscosity, which will be lower. Competitive tables showing comparative viscosities of oils are not to be relied upon unless the temperatures at which the tests were made are the same.

Heretofore it has been custom on the part of oil salesmen to recommend for high-speed motors, dynamos, planers, etc., oils ranging in gravity from 30 to 32, flash 380 to 480, viscosity 180 to 225; an oil for gas-engine use ranging in gravity from 23 to 25, flash 390 to 420, viscosity 200 to 350; general machine work, light line shafts, etc., a 23 to 26 gravity oil, 360 to 395 flash and

150 to 295 viscosity; steam-cylinder stock for pressures up to 150 lb., a 600 stock with about 6 per cent. tallow, for over 150-lb. pressure a 650 stock with 8 per cent. tallow, and for superheated steam but a very small portion of tallow with 625 stock. With too much tallow in superheated steam, steric acid is formed, which adheres to the cylinder walls and cuts the rings. The flash of a cylinder stock should not be below 500; the fire test is around 650; the Pennsylvania auto oils range in gravity from 30½ to 31, flash about 415, viscosity 215 to 225, amber color. For crusher bearings a cylinder stock compounded with a cheap black oil is generally used; for light spindle work, a water-white oil of about 34 gravity, 340 flash, low viscosity of 85 to 100. However, as previously suggested, with the new charactertistics being developed in oils, new standards are doubtless being created and lubricants will be selected more on the basis of what they will do than on what they show as to gravity, flash, viscosity, etc.

Oils for turbine lubrication must not emulsify with water, and those used in transformers and conditions where electricity is a consideration, must be free from conducting substances. For these purposes filtered oils are required. In the steam turbine the oil is exposed to such high speed and, consequently, high intermolecular friction, that it will change in character after a certain period of use. Further, the nature of the lubricant must be such that it will quickly settle and separate from the water of condensation with which it becomes mixed so that it can be used again. The reason why developments along this line are so slow is because mechanical engineers are handicapped in their lack of knowledge on oil matters, and because, heretofore, lubrication has not involved to any appreciable extent the chemical character of the lubricant.

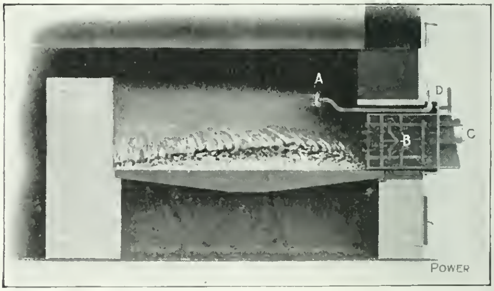
In a combustion engine the oil is not only constantly exposed to high speed and friction, but also to high temperatures. Both of these conditions tend to form substances rich in carbon by either decomposition or polymerization. The troubles are that oils will deposit carbon in the cylinders and start corrosion on the metal surfaces, and the spaces between the spark plugs become clogged. When applied to a vertical gas engine the oil will be divided into two parts, one working into the upper part of the cylinder above the piston, and the balance flowing back into the oil chamber below the piston. The part which comes into the cylinder is subject to high temperature, and the part which runs back, to high friction and some heat. In both cases the oil is greatly taxed chemically. With an ideal oil, that part which comes into the upper part of the cylinder should burn up completely without residuum, and the part which runs back should not form any asphalt or gum.

It is claimed that much trouble arises in getting results from good oils on account of a lack of scientific compounding of one oil with another. Oftentimes, it is a case of internal friction and disturbance in the oil itself due to the combining or attempting to combine two nonaffinity oils. The dealer in attempting to produce a certain gravity and viscosity by combining one grade of light oil with a grade of heavy oil without the necessary instruments and facilities to determine the physical and chemical constituents of each oil, and without knowing whether the two oils are produced from the same crudes, does not know what kind of an oil he is getting. True, this is bringing the discussion down to a fine point, perhaps too fine to be of value in general machine shop and factory work. In a large plant and in the operation of high-powered machinery the right oil is a big item. The above shows how futile it is for a buyer or large consumer to depend on specification purchases for results. It is a question for the oil producer and his engineer working in conjunction with the engineer or millwright of the plant to be supplied. Aside from the considerations of temperature of the bearing and the viscosity and wearing qualities of the oil, serious attention must be given to the design or construction of the bearing in relation to the duty imposed, the nature of the bearing lining, and the effectiveness of the lubricating devices and ways to keep an oil film between the surfaces of the bearing and the revolving shaft.

Aube Smoke Preventer

This device, adaptable to all furnaces burning bituminous coal, either alone or with sawdust or shavings, consists primarily of a patented furnace door which is pierced with apertures fitted with shutters and governed by an automatic regulator, so that air is admitted in the required amount. A furnace equipped with this smoke consumer is shown in the illustration.

To the inner side of the door is attached a boxlike structure projecting over the fire. In this device there is a succession of baffle-plates that can be independently adjusted so that the air in circulating around the baffles reaches a temperature sufficient to cause a high rate of combustion of the fuel in the furnace. These plates can be adjusted to conform to the peculiarities of each individual furnace.



Showing Baffle Box and Steam-Jet Nozzle of Aube Smoke Preventer

In connection with the device, a steam jet is used which throws a fan-shaped stream of superheated steam over the fire while the furnace is being stoked. The jet serves as a blanket and keeps the cold air from striking the boiler plates and cooling them; it also holds the smoke in subjection until the fire-door is closed and the preventer gets into action. The steam jets are controlled by an automatic regulator set to shut off the steam when it is not needed.

This smoke preventer, manufactured by the Aube Smoke Consumer Co., Springfield, Mass., calls for no special skill or training in its use; it is automatic, and merely opening the furnace door puts the device in operation; every part is easily accessible.

Rules for Firing without Smoke[*]

By Osborn Monnett[†]

SYNOPSIS—How to build, clean and bank fires. In carrying a thick fire the coal is dumped in piles instead of being spread over the grate. The volatile matter is distilled in amounts which the furnace can care for and less smoke is produced.

*

Building Fires

Cover the grate with coal to a depth of about 4 in., and build a wood fire on top, or throw live coals from another boiler into the furnace at the bridge-wall. The green coal underneath will then ignite and burn. As the coal in the front gradually ignites, the volatile matter must pass over the fire already on the grates. A live, good steaming fire can be built up in this way without producing dense smoke. Keep the doors cracked and the panels wide open, giving the fire sufficient air and allowing the fresh coal to be ignited from the top. This will keep the smoke down to a minimum. When the coal has fully ignited and has been well coked, fire six or eight scoops of coal on one side, beginning at the bridge-wall and filling up the low spots all the way to the front. Do not spread the coal but allow it to lie in lumps just as it leaves the shovel. Before the fire gets too low on the other side, and after the greater part of the volatile matter has been burned off from the last charge, fire an equal amount of coal on the other side as before, always keeping the panels wide open after firing.

When enough steam has been generated, use the jets, turning them on before firing and leaving them on until the bulk of the volatile matter has been distilled off. Always use the alternate method. For smokeless operation, hand-fired boilers burning coal exclusively should not exceed a capacity of 150 hp.

Cleaning Fires

Build up the fire on one side and let the other side burn down. Just before cleaning, "wing" over the live coal from the burned-out side and pull out the clinker and ash, cleaning the grates thoroughly. Cover the clean grates with green coal and push over live coal from the other side. When the cleaned side has become thoroughly ignited and the volatile matter has passed off, throw in coal to fill the spots not covered and pull the clinker and ash out of the other side. Cover the grates with green coal as before, winging over live coals from the opposite side. Keep the panels wide open and allow the fresh coal to ignite thoroughly. Never allow the fire to burn low before cleaning if carrying a heavy load, as there is a possibility of losing the steam pressure. After cleaning, follow up closely with the alternate method of firing until the fuel bed is thick enough to hold the pressure.

Carry as thick a fire as the draft will permit and do not spread the coal over the grates.

Banking Fires

Throw 15 or 20 scoops of coal on each side. Open the panel doors slightly, close the ashpit doors and partially close the damper. To break up the bank, level the fire, with the panel doors open, and start firing by the usual method, making sure the damper is wide open.

Keep the fire thick by the alternate method, using the panel doors and steam jets, and regulate the steam pressure with the ashpit doors. This insures a temperature in the furnace high enough to maintain the brickwork at the igniting point of the coal and promotes combustion of the volatile matter. At the same time, it keeps down the distillation of the volatile matter to a low rate, and by having the damper open and the panels cracked, the circulation of the gases is not retarded. Do not try to regulate the steam pressure by the damper or smoke will be produced.

The method just described is contrary to the general rules for firing, but its philosophy is explained in the following: If a shovelful of coal is thrown on a bright fire by the spreading method, every particle of that coal is immediately subjected to the intense heat of the fire and the volatile matter is rapidly driven off. If this is followed by more coal, the result is a volume of volatile matter which is beyond the capacity of the furnace to handle without dense smoke.

If, on the other hand, the fuel is fired in a lump from the shovel without spreading, there is a considerable quantity of the coal which does not immediately become subjected to the high temperature. The coal on the outside of the pile gives up its volatile and the coal within is not affected until the volatile matter has been distilled from the outside lumps. Furthermore, the volatile matter from the inner portions of the pile must pass outward through the incandescent outer layer of fuel much in the same way as in the underfeed stoker. In this way the production of smoke can be retarded, and the more coal thrown on to the fire at once, the less smoke. Two shovelfuls of coal fired by the spreading method on a clean, bright fire will make more smoke than ten shovelfuls of coal fired by the lump method. In practice, it will be necessary to determine just how much coal should be fired at once, but six or eight shovelfuls on a side with the draft operated according to the method ordinarily used will be found to be about right.

When a battery of boilers is to be fired, the fires should be fed by the alternate method, as before, passing from one boiler to another until they are all charged and then repeating on the other side of the furnaces. It should be determined by experiment, however, just how many furnaces can be fired consecutively without producing dense smoke, and after this has once been made known, the fireman should adhere strictly to the rules laid down in this regard.

[It is to be remembered that Mr. Monnett is smoke inspector of Chicago and that the rules in the above, as well as the recommendations in the previous articles of this series, apply particularly to conditions in the region where they burn the soft Illinois coal which is high in volatile matter. Further, being smoke inspector, the author's principal effort is naturally toward smoke prevention, rather than economy or efficiency, which are more or less of second consideration.—Editor.]

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[*]Copyright, 1914, Osborn Monnett.

[†]Smoke Inspector, city of Chicago.

Stopping Engine Rocking

By H. R. Low

On page 24 of Power for July 1, 1913, readers were asked to consider the question: "Why Does the Engine Rock?" The responses were gratifying, for not only were they instructive and helpful, but ample evidence that engineers not only read Power but think about what they read, and are not averse to imparting information that comes to them from their reading and thinking.

It may be of interest to learn that the rock has been eliminated. The method by which the cause of the trouble was found and results obtained was as follows: Indicator diagrams from both sides of the unit showing nothing radically wrong with the valve setting, some other cause had to be looked for. The belt was taken off and all four eccentrics, and both connecting-rods taken down. The quarter-box adjusting screws were slacked up, and the wheel marked and tried for balance. It was badly out. Examination showed the rim of the wheel to be $\frac{3}{16}$ in. thinner on one side than on the opposite. Four pieces of boiler iron were found secured to the rim by tap bolts, their total weight being 162 lb.

When these weights were put on, or by whom, no present employee at the plant has any recollection. It is supposed that they were put on by the builders to balance the wheel itself. Repeated trials resulted in the wheel coming to rest from any position with the chalk mark up, and the weights down. The weights were taken off and a marked improvement shown.

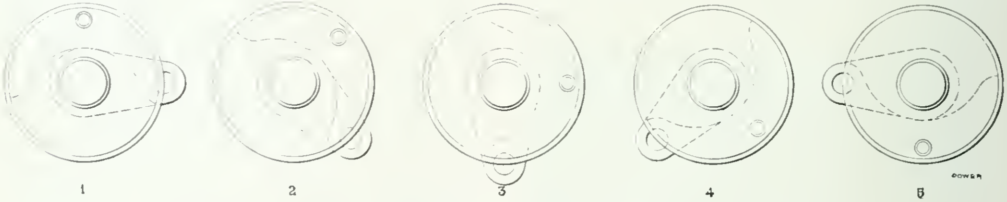
The engine was originally built with an arm crank on both sides, the crank on the small (16-in.) side having since been replaced by a disk crank. It was noticed that the position of the counterweight in this crank disk was on the same side of the center line of the shaft with the crank arm on the larger (20-in.) side, which had no counterweight at all; and when the difference in the weights of the two connecting-rods is considered it is seen that the larger rod with its boxes, strap, etc., tended to still further unbalance the unit. The illustrations showing the relative positions of the cranks and counterweight, and the positions they would assume for one-half revolution should make this clear.

The foundation, composed of brick and mortar with granite blocks under the cylinder, dummy stand and pillow block, had settled somewhat under the pillow block, throwing the greater part of the weight on two points, viz., the dummy-stand block and the front foot of the cylinder, the head end of the cylinder not bearing on its foot by 0.018 in. having broken the heads from four 1-in. bolts. It looked like a case of an unbalanced engine, and one out of alignment from a settled foundation. Evidently attempts had been made to stop the engine from rocking, as it was found that $\frac{3}{4}$-in. dowels had been put in between the cylinder feet and the cylinder casting, and two 1-in. tap bolts below the cylinder head, half in the cylinder casting and half in the rear foot.

The arm crank was split off by drilling a row of $\frac{7}{8}$-in. holes across its face along the center line of the shaft and driving in four steel pins tapered $\frac{1}{8}$ of an inch to 1 ft., and a disk crank ordered, having a suitable counterweight to replace it. The main shaft and wheel were raised and both bottom shells and quarter boxes taken out, and the shells rebabbitted. Jacks were placed under the cylinder and bed, and the cylinder feet and dummy-stand block removed, leaving the whole side resting on the jacks.

The foundation bolts were then taken out and thoroughly cleaned of oil and grease, and the holes burned out to remove as much oil as possible, so that the new grout would have a chance to unite with the foundation; channels, or gates being cut in the granite capstones to allow grout to be poured around the bolts after they were replaced and drawn up solidly.

The first move toward putting the engine together again was to square and level the bed with its mate. The feet and the dummy-stand block were next fitted to their positions, and foundation bolts replaced and drawn up and the engine again proved for alignment. Risers of brick and sand were built around the channels and thin grout poured in and allowed to dry out. The shaft was next let down into position, and the distance from the under side of the bearing to the pillow-block housing carefully measured, thus determining the amount of babbitt to be left in the bottom shell when bored. Then the shaft was bedded in and the new disk crank forced on.



Stopping an Engine from Rocking—Showing Disk Out of Balance

Perhaps it might not be amiss at this time to call attention to the method of fitting side shells, or quarter boxes. Some engineers are content to roll a box on the journal and scrape according to the marks thus obtained, and when the box shows a good general bearing to call it good enough and let it go at that. This is a mistake. Shells are usually bored in sets, i.e., the side shells resting on the bottom-shell casting, the top shell resting on both side shells, this being the position when they are in service. When fitting side shells, instead of rolling them on the bearing they should be dropped carefully into place and moved lengthwise of the bearing for marks and fitted accordingly. There is usually end play enough to admit of this being done, and this comes nearer fitting a box in the position where it is to run.

The crankpin boxes and eccentric straps were next looked after, requiring some scraping to restore alignment. Since making these changes the engine runs smoothly, for one 33 years old, and it is now possible to stand a nickel on edge on the steam-chest cover.

Heating the Largest Pier in the World

By Frank H. Jones

SYNOPSIS—Conditions of exposure and occupancy of the structure have offered unusual difficulties to the designers of this heating plant, and as the maximum demands are conjectural, considerable latitude of performance had be provided for.

Commonwealth Pier No. 5, at South Boston, Mass., now under construction by the State of Massachusetts, acting through the directors of the port of Boston, is the largest pier in existence. It is 1200 ft. long, 400 ft. wide, and of two-story steel and concrete construction. In addition to a magnificent headhouse containing the offices and warerooms, it has a floor area of about 900,000 sq.ft., nearly 700,000 sq.ft. being devoted to the handling of freight, which includes the entire first floor and the outer portions of the second floor. The remaining space provides for the passenger service and United States customs inspection.

The heating and ventilation of so large a covered area, jutting out into the harbor and exposed on all sides, offered, at the outset, many difficulties to the designers, therefore the layout as installed is essentially an experiment. No one can predict with certainty what the demands on such a heating plant will be when under maximum operating conditions at different seasons of the year.

Its peculiar interest lies in the adoption of two systems of heating supplied from the same isolated plant of four large boilers run at low pressure. Steam heating by direct radiation is used in the headhouse and the offices of the pier, while a system of warming the sheds by steam-heated air under forced circulation by motor-driven fans through sheet-metal airways was adopted. An extension of the steam system was also made to piping for melting the snow and ice of the shed roof gutters.

Air Heating

The equipment for this service includes the following: Low-pressure steam and condensation mains from a reducing valve in the headhouse to the fan groups; all connections of these mains with the air heaters for both steam supply and condensation return; heaters of form, surface and capacity adapted to the special requirements; fans, motors with link-belt drive and all electrical wiring, apparatus and connections; sheet-metal construction work for the airways and fan chambers and from the fan chambers to the points of discharge and distribution of heated air; fan chambers, roof intakes and all airway accessories.

Second Floor of Shed, Showing Warm-Air Ducts and Outlets

The steam for this system is delivered at the headhouse from the heating plant across Northern Ave. at practically boiler pressure. A reducing valve, with bypass of ample capacity for passing the maximum quantity of steam required by the entire steam service for the pier, is provided for reducing the pressure from about 50 lb. per sq.in for the high-pressure side to about 10 lb. per sq.in. on the low pressure. The condensation from all dry-valve house-heating pipes is discharged into the underground drainage system, and all traps are of the expansion type.

The air heaters of group No. 1, midway of the second floor of the shed, have a combined capacity for warming 70,000 cu.ft. of air per minute through a range of 60 deg. and with steam at 2 lb. gage pressure and with a velocity of air flow through the heater of 1000 ft. per min. Each of the heating coils of this group is divided into five sections, each separate section being completely valved for separate use.

The heaters of group No. 2, at the harbor end of the pier, are similar to those of group No. 1, except that they have a combined capacity for warming 50,000 cu.ft. of air per minute through the same temperature range and under the same conditions as those of group No. 1.

Each section of the heaters is drained through a trap and air vented through a valve connected into the piping. The sizes of the traps and valves are proportioned solely by the surfaces of the several sections of the coil.

The fans are of the multivane, double-inlet type, of a capacity to move the air quantities required for the respective groups against a pressure of 3/4-in. water column. The power input to the fans is specified as not to exceed 10 ft.-lb. per cu.ft. of air moved under conditions of maximum performance. The fans throughout are of metal and of construction suitable for marine service.

Twenty-five-horsepower variable-speed motors, with a speed control from 50 to 75 and 100 per cent. of full normal speed, drive the fans of each group.

The sheet-metal work for the airducts is of the best brand of galvanized iron throughout. U. S. gage No. 20 iron is used for all ducts of and above 16 sq.ft. in area; gage 22 for all sizes from 16 to 4 sq.ft., and gage 24 for smaller airways. All piping is braced and stiffened by small channel bars or angle-iron reënforcing where necessary.

The fan housings are mounted on the columns and iron ladders are dropped to the floor below for access to the platforms. The housings are constructed of 22-gage sheet metal on small angle-iron framework.

Direct radiation with vacuum is used for heating the offices of the first floor, and on the second floor the principal offices, the immigrants' detention rooms, doctors' rooms and inspector's quarters are also heated by this system. Cast-iron radiators are used, which it is specified shall weigh not less than 7 lb. per sq.ft.

All the pipes are so graded that the supply main slopes downward from the point of supply through the reducing valve to the extremity of the mains, and the return mains slope downward from their extremities to the point where connection is made with the main return to the pump room. The gradients are not less than one in 500. Hangers and other supports for all pipe work are constructed to admit of close adjustment for securing and maintaining the desired grade.

All piping under 10 in. is made up with screw joints, and at intervals of 150 ft. or less, flange joints are so placed as to facilitate the disconnection and replacing of any pipes without breaking the fittings. Expansion joints are provided by means of loops, circular bends, swivel joints and, in some cases, slip joints.

Where water and sanitary piping are run in places exposed to the danger of freezing, the steam pipes or condensation pipes are run along beside them or wrapped with them. Where such pipes are run for the sole purpose of protection, they are drained through expansion traps to the nearest connection with the return main where possible; otherwise, to the sewer.

All return mains within the shed are run above the ground back to the headhouse on account of the uncertainty of stability were they placed underground in the new earth fill.

For the melting of gutter ice and snow, pipes are run for blowing steam into the gutters of the lower sheds. These pipes run in the gutters and are perforated along their bottom lines with 1/8-in. holes spaced 12 in. on centers, the pipes being suspended 3 to 5 in. above the bottom of the gutters. The area of the pipeways for this service is not less than 1 sq.in. for every 80 holes.

The heating plant is a 55x90-ft., one-story brick structure across Northern Ave. from the pier. Steam service and return mains are run on overhead supports close to the viaduct leading to the second story of the pier.

Four 72 in. by 21 ft. 6 in. horizontal return-tubular boilers constitute the heating battery, and provision has been made for the addition of another similar unit should the operating conditions warrant. The settings are arranged in a single battery, with an air space between each pair of settings.

The boilers were designed for high pressure in anticipation of a possible installation of an electric-power plant, though it is expected that 100 lb. pressure will be suitable for the maximum service of the heating plant and that 60 lb. pressure will be adequate for all average requirements.

⁂

The Efficiency Engineer

By Joseph Harrington

Much is heard of efficiency engineering in these days, and the term has come to be applied to a number of varieties of engineering effort. Like most engineering subjects, efficiency work has been divided and subdivided until it is now necessary to indicate what kind of labor or operation is included in the engineer's particular department.

One of the most fertile fields of the expert is that relating to the economical use of coal. Of late years there has been a nation-wide campaign for smokeless chimneys, resulting in a rather extended knowledge of the basic principles of economic combustion and an undoubted improvement in the art of burning coal. It is probably true that there is no single operation in the whole system of human activity that is so universally encountered and so fundamentally necessary to the prosperity of the race as the development of power by means of the steam boiler. Transportation, mining and manufacture derive their first impulse from the expansive energy of steam, yet the amount of useful work that can be extracted from the black and innocent lump of coal is pitifully small. All but a small percentage is dissipated in one form or another. Energy enough to do the work of the world is passing to waste up the stacks of countless boiler rooms.

In these days of psychological influence, it is interesting to analyze the analyzer, or, in other words, to examine the present-day efficiency engineer and see what breed of man he is and what kind of atmosphere surrounds his daily work. What are the tools of his trade and what is the raw material upon which he tries to leave his impress?

Combustion engineering is in a transition stage, and "a little knowledge is a dangerous thing' 'applies with tremendous force and underlies most of the woes of the expert. Scarcely a watch engineer and boiler-room foreman but has read the technical press and informed himself to some extent of the requirements for efficient combustion. Also, and much more to the point, these same folks have formed opinions regarding their particular furnace, boiler or stoker which are most frequently inflexible, indestructible and eternally enduring. It takes a man who has fathered a furnace design and made it work to exemplify the fullness of parental love.

"What business," he exclaims, "has any man to come in here and even insinuate that anything could be better than this child of my engineering skill!" How can the real expert, with the experience of a thousand trials behind him, convince this man that his design is not up to standard, and that he should earnestly coöperate with the expert in proving that he is out of touch with the times?

And yet, in principle and in effect, this is exactly the situation that has to be met and overcome. Above all things, the engineer must have the cordial assistance of the operating force and their true and genuine coöperation in his endeavor to work out the admittedly difficult problems of the boiler room.

Arbitrary commands result first in creating a natural feeling of resentment. Besides a sound and thorough knowledge of his business, the efficiency engineer must then have tact. He must be broad enough to see the good in the other fellow's way and freely admit it, yet he must steadily press home his own good arguments in a way that will not offend. He must be a teacher, having the faculty of imparting knowledge in an interesting way. He has to be a keen judge of human nature, so as to adapt his manner of presentation to the comprehension and prejudices of his hearer.

First, education, and then incentive is necessary. More than one promising career has encountered the frosts of adversity because the fireman took no interest in his duties, and dropped all the carefully planned work as soon as the novelty wore off. It is all right for "the boss" to work nights, but the fireman's interest stops with the pay envelope. That is what he is working for, and the sooner this is generally recognized, the better for "the boss." As to the combustion expert, if one foot rests on knowledge, the other certainly rests on interest. All the skill at his command is required to create this feeling. All his art and all his judgment find room for exercise. He must secure in some way that element of personal interest that is the mainspring of sustained action. Efficiency in the boiler room is so much the result of skillful firing that the best-planned plant will give poor results if that skillful operation is lacking.

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Direct Current vs. Three-Phase System for Isolated Plants

By E. M. Marshall

SYNOPSIS—An analysis showing the direct-current, three-wire system to be superior in most cases for this class of service.

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With the rapid extension of alternating-current operation and the installation of single-phase and three-phase systems where electricity is purchased from a central station, there is a tendency to overlook some of the engineering involved when the small-plant management takes up the installation of an isolated-plant equipment. The alternating-current system is sometimes accepted when there are decided arguments in favor of direct current. The direct-current three-wire generator came into use some half dozen years ago, at about the time that power companies began active work for industrial motor loads, and has in many respects not been given the consideration that its design and operation deserve. In what follows the writer desires to present a few considerations that seem pertinent and deserving of serious thought when designing and laying out industrial-plant wiring to be supplied from an isolated plant.

Assume that the plant is of average size, with a demand for motors ranging from 2 to 25 hp. and a lighting service of not more than 20 per cent. of the total light and power load. For such a system the wiring and motor costs are important factors. In the first place, the requirements of the National Electric Code are an important although often neglected consideration in favor of the direct-current system, as will be shown. It is generally known that the National Electric Code requires that lighting circuits must be arranged so that one cutout will not be called upon for more than 660 watts. For the direct-current three-wire circuits, shown diagrammatically in Fig. 1, voltages of 110 and 220 are considered. The maximum allowable current per branch of the feeder circuit is then

$$\textit{watts} \div \textit{voltage} = 660 \div 110 = 6 \textit{ amperes}$$

and eleven 60-watt lamps may be used in each side of the circuit, or 22 lamps from one cutout.

With the three-phase circuit, Fig. 2, an arrangement of 11 lamps per phase violates the code ruling mentioned, for thirty-three 60-watt lamps on one cutout would represent 1980 watts. This, then, would call for a wattage per circuit on a balanced noninductive load of $I \times E \times 1.732$, or for a circuit of 33 lamps it represents a current of $1980 \div (110 \times 1.732) = 10.38$ amperes. And each fuse of each leg must be subject to frequent blowing if the circuit is used to maximum capacity as shown and 10-ampere fuses are installed. Also, if the underwriter's inspection is rigid, such an arrangement may not be approved.

If it is rigidly interpreted, that 6 amperes limits the current per branch, then for the three-phase circuits only $6 \times 110 \times 1.732 = 1143$ watts per three-phase circuit can be used, or a total of $1143 \div 60 = 19$ lamps, as against 22 for the direct-current three-wire circuit. With an arrangement of six lamps per phase, the current per phase would be $(3 \times 6 \times 60) \div (110 \times 1.732) = 5.6$ amperes, and the installation would pass inspection.

There seems to be some question as to the code ruling on this point of current-limiting feature. However, it is plain that a current of 6 amperes, if used as the limit in a direct-current system, should likewise be the limit for three-phase installations, where only 660 watts are allowed on one cutout. It is plain from Fig. 1 that this is the case for the direct-current circuit, for, as shown, this circuit is protected by a three-pole fuse block with fuses at *A*, *B* and *C*, and when each fuse has a normal capacity of 6 amperes, the circuit will not be interrupted. So long as an equal number of lamps remains in circuit in each side, a balanced condition exists, and no current flows through fuse *B*, and it can be removed without interruption of the circuit. Under the same conditions, however, if the fuse *A* is removed, the lights on that side of the circuit will go out and the fuse *B* is called upon to complete the other side of the circuit. This fuse *B* together with fuse *C* comprises a cutout in the interpretation of the code serving eleven 60-watt lamps at 110 volts, or 660 watts.

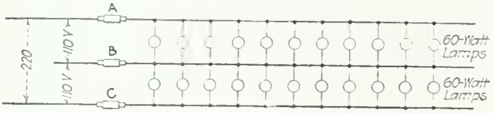

FIG. 1

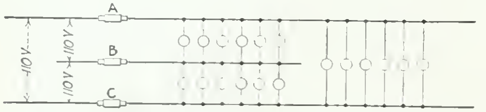

FIG. 2

FIG. 1. THREE-WIRE DIRECT-CURRENT CIRCUIT
FIG. 2. THREE-WIRE THREE-PHASE CIRCUIT

Consider now the three-phase circuit of Fig. 2, which is also protected by a three-pole fuse block, and shown with six 60-watt lamps per phase, or a total of 18 lamps. If the code were to rule specifically that 660 watts be allowable between any pair of wires in a system, then an arrangement of 11 lamps per phase could not be questioned. With an arrangement of six lamps per phase as shown, however, there is a current per phase of (3 × 6 × 60) ÷ (110 × 1.73) = 5.6 amperes. So that if fuse *B* was removed with all the lamps burning, a two-wire circuit would exist with six lamps burning at 110 volts and six series of two lamps on 110 volts. The six lamps on 110 volts would require (6 × 60) ÷ 110 = 3.2 amperes, and the six sets of two lamps in series burning at about half voltage would require 2.1 amperes, so that the current passing fuses *A* and *C* would then be 3.2 + 2.1, or 5.3 amperes.

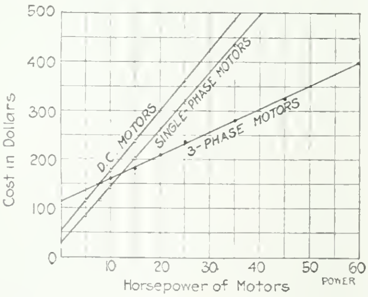

FIG. 3. RELATIVE COSTS OF DIRECT- AND ALTERNATING-CURRENT MOTORS

From this consideration the usual interpretation of the code that 6 amperes is the limiting feature in any circuit is substantiated, and consequently only 18 lamps can be used from one cutout on a three-phase circuit, while 22 lamps can be used on a three-wire direct-current circuit from one cutout.

Again, if the copper required for a two-wire system is taken at 100 per cent., that for the three-wire direct-current system would be 37.5 per cent. with all three wires the same size, while that for the three-phase system would be 75 per cent.

As to generator cost, the direct-current power-plant equipment will just about balance the cost of alternating-current equipment, and in no case will be more than 10 or 15 per cent. greater when no transformers are required for the alternating-current layout. The data curves in Fig. 3 give the relative cost of motors for direct-current, single- and three-phase systems, showing that for a plant where a large number of small motors are used, say none larger than 12 or 15 hp., the direct-current installation compares favorably as to first cost of equipment.

Reactive Interpole Shunt

By GORDON FOX

The function of the interpole in direct-current motors and generators is to provide for good commutation, not only at partial load and full load, but also upon overloads. The interpole has been found particularly effective when applied to motors driving machines having wide load fluctuations, and is likewise effective when used upon generators subject to frequently changing loads such as are met in railway work and mines.

Fluctuations in load upon machines of this kind are often very rapid. Since the interpole winding is of inductive character, these changes in load current and consequent magnetic intensity in the interpole winding tend to set up self-induced electromotive forces in the interpole circuit.

Most interpole windings are designed so that they will be stronger than necessary. Then they are shunted with german-silver resistance wire or ribbon until the proper strength is obtained to maintain a fixed neutral at all loads. Thus there are two parallel paths for the load current, one through the interpole windings, the other through the german-silver shunt. One of these circuits is momentarily inductive, the other is noninductive; hence, when rapid load changes occur, the inductance of the interpole winding causes it to lag in responding to the changes. If a sudden increase in load occurs, the interpole inductance causes more than the proper proportion of the current to flow momentarily through the noninductive shunt, making the interpole strength momentarily less than it should be, and sparking or flashing is likely to occur for an instant. With frequently and suddenly changing loads, the interpole will thus fail to adjust itself quickly to the changed conditions and sparking will occur with each change.

If the german-silver shunt around the interpole be also inductive, as much or more so than the interpole, then sudden load changes will be properly divided, as though both windings were noninductive. It is hardly necessary to obtain an exact inductive relationship, but it is well to wind the interpole shunt upon an iron core so that it will have sufficient inductance to cause the main interpole winding to assume instantly its portion of changes of load.

Comparing Power-Plant Efficiencies

By Morgan B. Smith

SYNOPSIS—Pounds of coal burned vs. B.t.u. per kilowatt-hour generated.

✻

There seems to be a fairly general lack of appreciation in many power plants of the real relation that exists between the fuel consumed and the current generated. Too many by far of our plants are content to figure the relation in terms of mere pounds of fuel vs. current generated, losing sight altogether of the amount of actual heat supplied per unit of current. That it is a fallacy to speak of fuel in terms of mere weight is now recognized as a fact and that it is true that the fuel should be considered as so much available heat energy is equally well known.

It is with the idea of making plain the above fallacy that the following four power plants are compared, figuring their relative efficiencies in terms of pounds of coal per kilowatt-hour and in terms of B.t.u. per kilowatt-hour, showing that these plants should be rated in terms of heat supplied per kilowatt-hour generated rather than in terms of mere weight of coal consumed.

These four plants are operating on four decidedly different coals, the analyses of which are given in Table 1.

TABLE 1. ANALYSIS OF THE FOUR COALS

Plant No.	Coal Used	B.t.u.	Ash	Fixed Carbon	Volatile	Sulphur	H_2O
1	Boomer	14,070	8.4	61.65	28.60	1.00	6.85
2	H. V. slack	12,190	13.5	52.40	36.00	2.00	8.00
3	Illinois	9,639	13.50	41.00	32.00	4.80	15.80
4	Texas	7,218	7.75	32.00	28.50	0.80	34.10

The four plants are of about the same capacity and are operating under almost identical conditions. For the sake of comparison, plants 1 and 2 will be considered together and plants 3 and 4 in turn in the same manner, showing data covering the period January to June. The charts attached show graphically these same figures.

TABLE 2. COMPARATIVE DATA FROM PLANTS 1 AND 2

Plant	Coal	Month	Av. Fuel B.t.u.	Kw.-Hr. Av.	Lb. Coal per Kw.-Hr.	B.t.u. per Kw.-Hr.	Kw.-Hr. per Million B.t.u.
1	Boomer	Jan.	14,000	960,700	3.55	49,000	20.40
		Feb.	14,100	985,960	3.50	49,350	20.25
		Mar.	13,980	999,870	3.62	50,608	19.75
		Apr.	14,160	1,000,060	3.52	50,268	19.85
		May	14,100	1,000,360	3.45	48,645	20.51
		June	14,080	1,000,800	3.42	48,134	20.80
		Av.	14,070	991.292	3.507	49,334	20.26
2	H. V. slack	Jan.	12,250	975,600	4.10	50,225	19.90
		Feb.	12,400	980,700	3.96	49,104	20.35
		Mar.	12,100	1,000,060	4.00	48,400	20.62
		Apr.	12,090	1,000,030	4.05	48,965	20.40
		May	12.350	1,001,080	3.92	48,412	20.62
		June	11,950	1,001,350	4.21	50.310	19.87
		Av.	12,190	993.303	4.04	49,236	20,293

Comparing the above averages it will be noticed that the loads carried are almost the same; that the pounds of coal consumed per unit of current generated vary widely; that in spite of the variance in the weight of fuel consumed the actual heat utilized per unit of current generated at the two stations agrees within small limits.

If the relative efficiencies of these two stations were to be judged in the old manner, namely, in terms of weight of fuel only, it would be concluded that plant No. 1 is operating at considerably higher efficiency than plant No. 2. Judging them in terms of heat utilized per unit of current generated the conclusion would be that the two plants are operating at about the same degree of efficiency.

As a matter of fact, plant No. 2 is actually operating under more adverse conditions and so is to be rated at least even with plant No. 1 if not actually above it. Plant No. 2 is handling more coal and more ash than plant No. 1 to generate the same amount of electrical energy. Plant No. 2 is splendidly equipped for handling both coal and ashes so that the cost for handling is kept at a minimum, although still higher than in the case of plant No. 1.

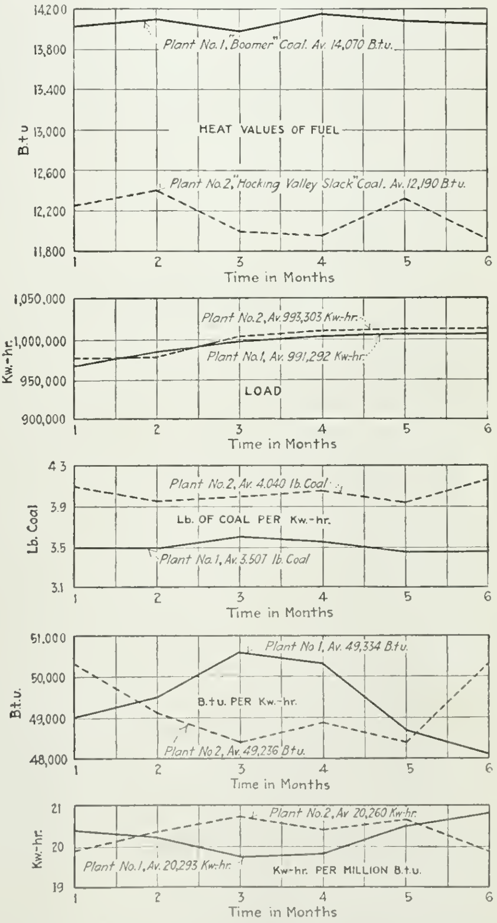

Fig. 1. Graphical Indication of Results from Plants 1 and 2

Plants 3 and 4 are operating on fuels which vary more widely than those utilized in plants 1 and 2, and the loads carried are not so nearly alike. Plant No. 3 has two factors to contend with, both of which tend to lower efficiency, namely, a lower load and a poorer coal for fuel, compared with plant No. 4. In spite of this the two plants are operating at about the same degree of efficiency.

Data on these two plants for the period January to June show the results given in Table 3. These are also shown graphically in Fig. 2.

In this case the difference in weight of fuel consumed per kilowatt-hour generated is about 2 lb., yet when the heat value of the two fuels is considered it is found that these two plants are running at nearly the same efficiency.

TABLE 3. A COMPARISON OF PLANTS 3 AND 4

Plant	Coal	Month	Av. Fuel B.t.u.	Kw.-Hr. Av.	Lb. Coal per Kw.-Hr.	B.t.u. per Kw.-Hr.	Kw.-Hr. per Million B.t.u.
3	Illinois	Jan.	9,149	967,800	5.68	51.966	19.22
		Feb.	9,319	980,700	5.45	50.789	19.65
		Mar.	9,983	1,000,700	5.30	52,910	18.90
		Apr.	9,790	999,980	5.37	52,572	19.00
		May	9,655	1,000.150	5.41	52.234	19.13
		June	9,940	1,001.350	5.33	52,980	18.85
		Av.	9,639	991,780	5.42	52,242	19.125
4	Texas	Jan.	7,110	867,000	7.31	51,974	19.25
		Feb.	7,360	910,000	7.25	53,360	18.75
		Mar.	7,080	889,700	7.50	53,100	18.80
		Apr.	7,180	993,450	7.35	52,773	18.95
		May	7,400	900,160	7.28	53,872	18.55
		June	7.180	913.700	7.32	52,558	19.05
		Av.	7.218	895,660	7.33	52.939	18.89

In considering each of these four plants only the heat values of the fuels in relation to the load carried have been taken up. There are other factors to be considered in the final judgment of efficiency, such as coal and ash handling, wear and tear on equipment, etc. With these we are not now concerned; they must work themselves out to the best advantage in each case. It may be of interest to state that in the four plants mentioned the fuels were all mechanically stoked. Plants 1 and 2 had overfeed grates; plant 3 being underfed and plant 4 being fitted with chain grates.

The general performances of these plants represent in a remarkable degree the average efficiency of many of our power plants. They show the wide errors into which operating engineers may be led in judging the performance of a plant without first knowing all the conditions. This is especially true in the matter of the relation of the fuel used vs. the current generated.

It was just such a misapprehension of facts that led the writer to give the facts relative to plants 1 and 2 and to supplement these with figures on plants 3 and 4. The statement had been made that plant No. 1 showed a much better performance than did plant No. 2, the speaker going so far as to criticize plant No. 2 severely. Investigation brought out the facts given above and at once stopped all criticism of the No. 2 plant. It also showed that plant No. 1 was not doing as well as it had first seemed.

It often happens that, although truth hurts at times, it really does no end of good in power-plant practice, for it gives facts to work upon. Guesswork takes a back seat and stays there.

As a matter of fact, the four plants are doing about the same, although the weight of fuel burned per unit of current generated varies all the way from 3.5 lb. to 7.33 lb. of coal per kw.-hr. generated. The B.t.u. supplied vary only from 49,334 to 52,939 per kw.-hr. generated, a variance not at all in proportion to the difference in the weight of fuel burned.

Finally, when speaking of fuel consumed, be sure to know the exact nature of the fuel in question; also know the load carried; for these two factors are preëminently important in arriving at a just measure of a power plant's efficiency.

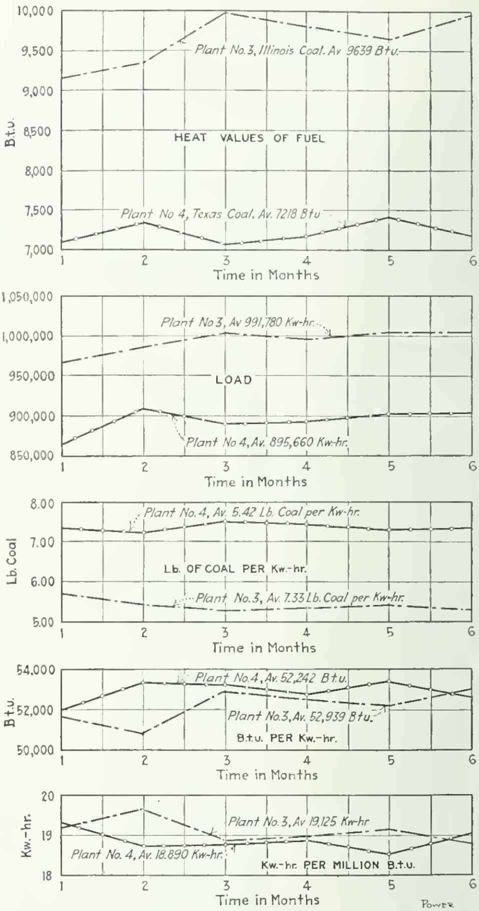

Fig. 2. Chart of Data from Plants 3 and 4

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Some Characteristics of Water—Water is at its maximum density (weight) at 39.1 degrees F. From this temperature it expands by heat or cold. A vessel levelfull of water at this temperature will overflow if the water is either heated or cooled. When formed into ice at 32 deg. it will have expanded one-twelfth ($^1/_{12}$) of its original bulk (at 39.1 deg.). The weight of 1 cu.ft. of ice at 32 deg. and that of 1 cu.ft. of water at 300 deg. will be nearly the same, 57.2 to 57.5. Water at 60 deg. weighs 62.35 lb. per cu.ft. For ordinary calculations, 62½ is sufficiently accurate. Water evaporates at all temperatures. It dissolves more substances than any other known substance. Water has a greater capacity for heat than any other known substance.

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Oklahoma Breaks Coal Record—Coal as mined in Oklahoma in 1913 to the amount of 4,165,770 short tons, valued at $8,542,748, both record-breaking totals for the state, according to figures compiled by E. W. Parker, of the United States Geological Survey, in coöperation with the Oklahoma Geological Survey.

Editorials

Conserving Niagara

Prospect of action by Congress in the matter revives the agitation of the controversy over Niagara Falls. Which way shall they be conserved, for their scenic beauty or for their power? There are rabid partisans on both sides of the question. At the one extreme are those who want the Falls restored to their pristine glory, and the power houses and all evidences of sordid mankind removed, while extremists of the opposite kind will not be happy so long as a drop of water is unutilized for power generation.

So compelling are the arguments on both sides of the question that it is difficult for one not yet committed to either side to decide just where he will stand, and for the present we are trying to keep in the middle and agree with everybody. We are pained at the thought of any impairment of the beauty and grandeur of the cataract, but at the same time, as engineers, we hate to think of the extravagant waste of power just for a spectacle. When the question of affecting navigation comes in there is no room for argument. Shipping on the Great Lakes is too important to be subserved even to power production.

Nothing is much more imposing and impressive than a conflagration, but we call anyone who sets destructive fires so as to see the flames an incendiary, or firebug—an enemy to society. No properly balanced person would advise the ruthless burning of hundreds of thousands of tons of coal to make a huge bonfire and keep it going for the benefit of tourists. Sometimes an oil tank or a mine takes fire accidentally and people travel great distances to see the blaze, but those whose money is going up in the smoke spare no effort to extinguish the fire.

In a sense, every undeveloped water-power is a burning coal mine, for coal of the equivalent power would be saved if the water-power were utilized, and by just so much would the exhaustion of coal be postponed.

We think that if we owned Niagara we would feel that we were paying pretty heavily to entertain the public if we continued to let the water flow over the edge instead of down penstocks. Merely because we hold no stock in the Falls is no excuse for our being so selfish as not to care how much water is wasted. As a state or national property, the Falls belongs to the taxpayers and they are all chipping in their mite to maintain a world's attraction, all of which may be very commendable.

Again, we picture our descendants shivering in the cruel winter for want of coal to make a fire, and can hear their condemnation at our extravagance which hastened the time of their suffering. Is it fair to gratify our eyes and our sense of the beautiful at the expense of the actual comfort of others? True, it may seem like borrowing trouble to be worrying about our many-times-great-grand-children, like the old maid, who was crying because "s'posin' she got married, an' had a child and it should die." There may be as many and as remote chances that the dire consequences will be averted. Heat made by electricity, in turn hydraulically generated, may be cheaper than coal before so very long, or other ways found to keep our surroundings at temperate temperatures.

So we have reasoned back to where we started and can only conclude that we must decide whether "the game is worth the candle." Let us have all the show we can for the least money; let us take water from the Falls until their beauty would be hurt more than the extra power would be worth, and let us leave as much water as we can afford to throw away.

After all, we are not inconsistently prodigal so long as we burn up coal as we do for unnecessary illumination of our "White Ways" and for night advertising signs.

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Harmony between Employer and Engineer

In the last issue we referred editorially to what we termed "business grease." This had reference to the sort of relations between buyer and seller that are lubricants in the sense of eliminating friction between the producer and the consumer.

The thought is appropriately extended in the cartoon of this week, entitled, "A Smooth Running Bearing," typifying the employer and engineer as the two boxes in a rod end. Correct engine-room management is the force driving up the key of efficiency to take out the knocks in the bearing and adjust the boxes to a nice running fit on the journal. Finally, the oil of harmony, coming by way of the employer, as it should, completes the provision of the necessary conditions for "a smooth running bearing."

The more one studies this picture the further the aptness of the analogy will be seen to extend. In his management of the engine room, the engineer must not be too aggressive nor bring unnecessary pressure to bear on the employer, so that he will become hot, for the engineer will feel the effects of this himself.

A little thing not to be overlooked is the importance of shims between the boxes. This might suggest that there should not be too much intimacy between the employer and the engineer, or, at any rate, that they should be kept apart enough not to interfere with each other. The employer should not meddle with the engineer in the latter's conduct of the engine room; no more should the engineer attempt to tell the employer how to run his business.

When the bearing is first assembled the boxes must be scraped until there is good contact with the journal. Obviously, it is true also that the employer and the engineer must each be well fitted to his place if things are to continue to go smoothly. While the boxes are new and until the engineer and the employer become acquainted and accustomed to one another, it is well to run a little slow, watching for necessary changes of adjustment and not putting on too much load until these two members have worn into place.

Again, how useless would be the bearing without either box! The employer cannot operate his plant without the engineer and the engineer has no plant to operate without the employer. If this interdependence were not so often overlooked or forgotten, there would be less discontent on both sides, for then there would be more effort to coöperate.

In the natural order of things the employer is on top and the engineer on the bottom, but they get equal shares of the load, and they have their ups and downs together.

The boxes must be of the right composition according to the service to be rendered and the men, too, must be made of the right stuff to do what is expected of them.

And so the comparison might be extended indefinitely, but enough has been said to emphasize the need of the employer and the engineer working together, each doing his part.

Overloaded Stacks Due to Excess Air

Of all the many things with which the engineer has to deal, air is one of the most common and one of the most important. For the successful and economical combustion of fuel, it must be supplied in quantities which are not ordinarily easy to determine. In most plants, the quantities supplied are greatly in excess of those practically required.

This brings up the interesting question: How many flues and stacks are overloaded, condemned as of inadequate capacity because they are required to pass such great quantities of excess air? Every pound of air that goes into the furnace must be passed by the flue and stack. Both have a limit to their capacities, just as has a pipe line carrying water, air or any other medium. Plant designers are often accused of making flues and stacks too small for overload condition. There may be numerous places where this condition prevails, but it seems evident that in many plants so called overloaded flues and stacks are overloaded with too great an excess of air which never should have entered the furnace.

Uniform Boiler Specifications

The outlook is bright for an interesting session at the public hearing called for Sept. 15 by the Committee on Standard Boiler Specifications of the American Society of Mechanical Engineers. At the annual meeting of the American Boiler Manufacturers Association, to be held the first week in September, the subject of uniform boiler specifications will be discussed, and it is more than likely that there will be developed some very definite propositions to be submitted at the later meeting, to which all interested in the subject are invited.

The occasion of the agitation is the present deplorable lack of uniformity, not to say consistency, between the laws and regulations now in effect in the various states and cities governing the construction and operation of boilers. There is no disposition to rebel against laws that make for greater safety in the handling of steam-plant equipment; quite the reverse, for it is to the interest of all parties concerned—manufacturers, owners and users—to decrease the attendant danger, but it is important to eliminate, so far as possible, unnecessary requirements which are at variance in different localities, for they are embarrassing to the manufacturer and the source of needless expense to the purchaser.

It was the expectation that the question would be widely discussed at the spring meeting of the mechanical engineers in St. Paul and Minneapolis, but, by action of the council, the discussion was so restricted in its latitude that little of value was brought out. As a consequence, this meeting in New York was decided upon as an individual undertaking of the committee, so that the views of all concerned might be brought out.

In the meantime, suggestions and criticisms have been asked, to be submitted in writing not later than Aug. 15. The evidences of interest which are being manifested in all quarters indicate that the meeting will be much more largely attended and of greater significance than even the committee anticipated, and the prospect is encouraging for accomplishment of the big purpose which has grown out of the committee's original work.

The meeting will be held in the Engineering Societies Building, 29 West 39th St., New York City, at 10 in the forenoon of Sept. 15. Thereafter the committee will present its report for discussion at the annual meeting of the society in December.

Panama Boiler-Inspection Rules

Rules for the inspection of stationary boilers operating in the Canal Zone have just been issued by an executive order of Gov. Goethals. A study of these regulations would indicate that the Massachusetts rules had been consulted, although more attention is paid to the inspection and to fittings and less to the actual construction of the boiler itself. This is as might be expected, for it is improbable that any boilers will be built in Panama.

Annual internal inspections and hydrostatic tests are prescribed, preferably six months apart, and whenever flues are removed from a boiler, those in charge must notify the inspection service, so that an internal inspection may be made. With regard to the care to be exercised in making the internal inspection, the rules say:

> The entire interior of the boiler, where accessible, must be examined for cracks, pitting and grooving. The edges of plates, laps, seams and joints where cracks and defects are likely to develop and any defects which an external examination may have indicated, must be given especially careful examination. . . . Boilers having lap-joint longitudinal seams shall be examined with care to detect grooving and cracks at the edges of seams, and any sheets showing such cracks shall be condemned for service and not repaired.

From the foregoing precautions, it is evident that the mechanical department of the Canal Government, which formulated the rules, has been a keen observer of recent boiler explosions.

Of equal importance with the rules pertaining to inspection are those providing for the care and safe operation of boilers, the idea being that the fireman, by adopting precautionary measures, can do as much, if not more, than the inspector to prevent boiler failures. In this connection, the fireman is warned not to draw the fires in case of low water, but to immediately cover them with ashes or fresh coal and close the ashpit doors. We are glad to see this point emphasized, as it would undoubtedly be the first impulse of many firemen under such circumstances to draw the fires, whereas this is likely to intensify the heat and make matters worse.

Correspondence

A Boiler Test

I am interested in the comparative boiler test conducted by C. R. McGahey, as published on p. 21, July 7, and note the increased evaporation from 7.99 on the test without the steam jets to 8.25 with them. It has not been stated whether the steam available for commercial purposes per pound of coal was greater when using the steam jets, which would be necessary to demonstrate that there was a saving of about "31 lb. of coal to the thousand pounds burned."

It would be instructive to know the number and diameter of the steam jets, the length of time they were on, and whether they were throttled. This would be an approximate guide as to what proportion of the increased boiler horsepower (144 against 127.25) is chargeable to the operation and if the final result will show any net saving in coal.

J. D. MacLean.

Toronto, Ont., Can.

The conditions were the same on running the boiler test as for output. The steam for maintaining the jets was taken from the boiler under test, and there were four jets used, having a nozzle with an opening $\frac{1}{16}$ in. diameter. These were taken from the flue blowing pipe and had but one control valve. This was only slightly open, and therefore throttled the supply. My version of the matter is that the difference is due to the increased draft conditions, which were clearly set forth, so that it could be seen that this was the true state. There could be no gain from the use of steam above the fire.

C. R. McGahey.

Baltimore, Md.

⁂

Preheating Furnace Air

M. A. Olmstead's letter on this subject on page 24, July 7, surprised me in the high saving (15 per cent.) which he believes he is making. While this amount is well worth saving, there are, however, some facts that should be considered before going to much expense in special equipment—i.e., the principles involved. For example, one pound of Kansas coal has on an average 12,500 B.t.u. and under running conditions 17 pounds of air per pound of coal is used, so that the products of combustion per pound of coal will be 18 lb., a useful approximate number to remember.

When the air is fed in the usual way, we can, without much error, assume it to be 80 deg. Raised to 190 deg. by the preheater, the specific heat of air at this temperature is about 0.237, therefore the heat absorbed is

$$17\ lb. \times 110\ deg. \times 0.237 = 443\ B.t.u.$$

Under these conditions, the one pound of 12,500 B.t.u. coal, together with the air, supplies 12,943 B.t.u. Thus, to make the same amount of steam as before, we would require only

$$\frac{12,500}{12,943} = 0.965\ lb.$$

of coal where one pound was used before. This would be a saving of

$$1 - 0.965 = 0.035\ lb.$$

or 3.5 per cent., which shows that the greater part of the saving must be due to other causes. It would be interesting to learn more of the particulars.

G. P. Pearce.

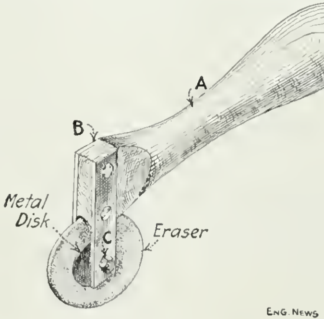
Moline, Ill.

⁂

Drafting Kink

A description of this eraser handle was published in the *Engineering News,* of June 11, and may prove of interest to readers of Power.

The handle A is of wood, to the end of which the metal strips (preferably copper or brass) B are fastened, as shown. The small bolt through the ends of the strips clamps the eraser firmly in position.



Handle for Eraser

Anyone having occasion to use a circular eraser frequently will appreciate the relief from injury to the fingers and the fact that the eraser may be used after the metal disks have been removed.

John E. Cahill, Jr.

New York City.

⁂

Machinist Engineers

On page 930, June 30, an article by John Thorn appeared under the above caption, to which you have taken exception. I quite agree with Mr. Thorn, and venture to say that not many engineers are machinists. If we must be machinists, then why be engineers, when the average wage of the former in this country is 45 to 50c. per hour, and the engineer, with few exceptions, gets 30c. or even less.

Large companies nearly always keep a machinist, and, as Mr. Thorn says, in the plant so small as not to require the service of one, they very seldom have the tools for doing that class of work, so that knowledge of the machinist trade would be of little use to an engineer. There are enough jack-of-all-trades in this country already. When an engineer has thoroughly mastered th handling of steam machinery in both theory and practice, along with a knowledge of electricity, he has gone far enough; anything outside of this is butting into another man's trade.

I aim to make myself as efficient as I can in the handling of steam and electric machinery by hard study and conscientious work. A fair knowledge of the trades can be gained by reading books and magazines, but to get the practice in each would take a lifetime of apprenticeship, and the victim would die of starvation long before he had finished.

I do not mean that an engineer should not be able to make his own common repairs, for he certainly should, but when it comes to a job requiring mechanical skill and fineness out of our regular line of work, then we should call in that particular tradesman to do it.

N. C. Gleason.

Red Deer, Alta., Canada.

[The two previous articles agree with this that the engineer should "be able to make his own common repairs," and "if required to do this work frequently he will soon acquire a skill equal to a machinist's," and "certain it is that, in either case, doing or supervising, the more positive and accurate the knowledge, the more satisfactory will be the results." See also the second paragraph, beginning with the second sentence, on page 926.—Editor.]

⁂

Blowoff Pipe Failures

On page 72, July 14, John Thorn wants to know why the lightning should come down the chimney, strike the blowoff pipe and injure nothing else. In my opinion, the chimney and boiler were large enough to conduct the lightning to the blowoff pipe without their being damaged, but the blowoff pipe was so much smaller that the increased resistance was great enough to melt the pipe.

Willis W. Nelson.

Spokane, Wash.

⁂

Automatic Cutoff Engine

The type of governor described by Alfred Butcher, on page 848, June 16, will give good regulation if properly cared for. The chief trouble is in properly lubricating the eccentric hanger-pin bearing. This (and the link bearings) is generally equipped by the engine makers with a hand-compression grease cup, especially unsatisfactory on engines which run almost continually. The reason is that it is practically impossible to exert the necessary pressure on the screw cup to force the grease very far around the pin. This must be done, of course, while the engine is idle. When it is running, the pin merely oscillates and does not turn completely over. The result is that the side of the pin opposite the grease cup gets very little, if any, lubrication, and the pin soon becomes rusty, causing trouble with the regulation and rapid wear.

We have found a way out by the use of spring-compression cups and a light grease. These cups will produce good results because the spring pressure, acting on the grease while the pin is oscillating, will force it around the pin. Before we put spring cups on it was necessary to use a heavy hammer to take the pins out, and the pin was always rusty. Now, when a pin is taken out after an all-winter run, it is as bright and in as good condition as when it was put in. A little practice will enable the operator to select a grease of the proper consistency and to adjust the spring to the right tension.

H. G. Gibson.

Washington, D. C.

⁂

A Hot Fire and No Water

At 6:30 a.m., June 11, a boiler failure occurred at the plant of the Crescent Macaroni & Cracker Co., Davenport, Iowa.

The night fireman was preparing to start up the plant for the morning when the gage-glass broke on one of the two boilers connected.

He closed the valves and, after putting in a new glass, so opened or set them that the glass showed three gages of water. Thinking he had too much, he continued to blow the boiler down, as the glass still showed three gages notwithstanding that the safety plug had melted and blown out when the boiler became dry.

Even after the plug blew out, a hot fire was maintained, until the bottom of the boiler bagged about 7 in. The iron stretched until very thin and burst apart, leaving an opening about 2 in. wide. The steam then extinguished the fire.

At the time the boiler burst there was a pressure of 50 lb., although when the glass broke both boilers were carrying 110 lb. They were return-tubular boilers, 60 in. by 18 ft. The boiler setting was not disturbed in the least. One stay rod was pulled apart and the other was stretched until it buckled up among the flues when the boiler was cooled. Both heads were slightly bulged.

W. M. Bartlett.

Davenport, Iowa.

⁂

An Interesting Cylinder Failure

This article, on page 60, July 14, brings to mind an accident three years ago on a steamship, equipped with twin-screw engines of the vertical, triple-expansion type. Shortly after leaving port the valve broke on the intermediate cylinder. We took out the broken pieces and ran on the high- and low-pressure cylinders, the intermediate cylinder acting as a receiver. Everything went well for about two days, then, about 3 a.m., a slight groaning noise started in the high-pressure cylinder, and increased so fast that I had to slow down. I examined the rod and it was found perfectly cool.

We had no lubricators or any other way of putting oil in the cylinder, so the only thing left was to make the best speed possible, about one-third, full speed being 185 r.p.m. I reported to my relief, at 6 o'clock, how it had been acting. At 9 o'clock the engine was up to speed again, but about 9:15 the groaning noise became suddenly heavy and the engineer tried to locate the trouble. While he was looking up at the packing gland, the cylinder exploded, making three openings its entire length, and knocking the bottom of the cylinder out, so that it fell down and rested on the crosshead.

It also pushed the rod through the piston, the piston dropping down and resting on the cylinder bottom. One peculiar thing about the explosion was that, aside from getting dirt in his eye, the engineer was not injured. We found that the piston rings and the cylinder walls were smooth and glossy, therefore, the theory of gripping was eliminated, and we could not find the cause of the groaning, and I have been unable to satisfactorily explain it. The cranks were set 120 deg. apart and were counterbalanced. The valve-gear was the link motion. The pressures were throttle, 125 lb., low-pressure receiver 40 lb., and the vacuum was 25 in.

I would be pleased to hear some theories as to the cause of the groaning and also the explosion.

M. C. MAYNARD.

Charleston, S. C.

⁂

Small Air Compressor

Frank Richards criticises on page 927, June 30, a compressor described by me. Realizing that others may be laboring under the same difficulty, I would remind him that air is one of the lightest of gases, water being something like 813½ times its weight. Air is compressible to a great deal less than its normal volume, while water, we know, is practically noncompressible. This is the reason for the difference in the amount of clearance in the water pump and the air compressor. In other words, the difference in the two designs is due to the solidness of water and the compressibility of air. "Tight packing" would not permit of a steam pump being used as an air compressor for pressures exceeding a few pounds, as the piston would only compress the air in the cylinder, and its expansion would again fill the cylinder, while water would be forced through the discharge valves and the return of the piston would draw in another charge.

I will admit that, from a practical standpoint, water as a medium for compressing air has been tried and proved a failure from the standpoint of economy, aside from systems utilizing its gravity, but in case of a small amount being in demand with no other means available, the combination described works quite satisfactorily. It is a regrettable fact that a great number of us are so little versed on the handling of air as compared with the other elements.

FRANK W. HUDSON.

Klamath Falls, Ore.

⁂

Oil Explosions in Air Compressors

John J. Oelrich told of an explosion in air pipes on page 72, July 14. This seems to have been a typical occurrence, and although the account is short, all the essential particulars may be gathered from it if we read between the lines.

It seems singular that the pipes could have been so badly knocked to pieces and yet not damage the cylinder. The pipes should be just as strong in proportion to their size as the cylinder. The conclusion must be that there was no explosion in the cylinder. It has frequently happened with single-stage compressors that oily deposits in the cylinder or pipe take fire, and the flame is carried along into the receiver and pipes beyond, with no serious results beyond the excessive heat. After the compressor has been stopped and cooled off, operations may be resumed.

Sometimes, however, as apparently in this case, the combustion is so rapid as to amount to an explosion. It is fortunate that the proportions of oily vapor and of air to form an explosive mixture are narrowly limited; otherwise, these explosions would be more frequent. In gasoline-engine practice, the proportions are confined to narrow limits, but outside these limits either way, the mixture is nonexplosive.

Oil can be limited in compressed air systems so that neither ignition nor explosions will occur. Such occurrences do not come by chance but by invitation, or at least by permission.

A fusible plug will often give timely warning of a possible ignition, or if that should occur, to prevent the more disastrous explosion which might follow. When so warned, it is always best to instantly stop the compressor and the flow of the air.

FRANK RICHARDS.

New York City.

⁂

Hints on Starting a Compression Plant

Mr. Anderson's criticism in the July 7 issue of my article in the June 2 issue, was appreciated. The criticism relating to the density of the brine should, as Mr. Anderson pointed out, have read "70 to 90 deg." on the salometer, instead of "70 to 90 Beaumé."

Mr. Anderson does not quite understand me when I say: "All double-acting machines have equalizers; see that they are open when starting." If he will consider the machine he mentions, he will recollect that the equalizing cocks on every one of these machines, single- or double-acting, are on the ammonia cylinders, and one will have a hard time to start such a machine if they are not opened first. It is important to close them when the machine is running, for, if neglected, it will not do the required work. These equalizing cocks are also useful when the compressors are pumped out, as they serve to let oil mixed with ammonia out of the compressor.

I further said: "The water over the condenser should not be turned on until the pressure gages indicate the pressure usually carried. Sometimes I have run a dry-gas machine in cold weather for over half an hour before the gages indicated the pressure we usually carried." I found that I had the system in good working condition much sooner by turning the water over the condenser after the ammonia was turned on.

Our condenser has been in use for the last eighteen years, and is still in good condition. It is very true that the direct-expansion system eliminates brine pumps, tanks, etc., but though more expensive, the brine system for a small plant is more economical and practical than the direct system. The brine system is used in many small plants having only one engineer; the engine is run during the day and shut down during the night while the brine pump is kept running, the refrigerating capacity of the cold brine being enough for the night.

W. L. KEIL.

Philadelphia, Penn.

Engineers' Study Course

Elementary Mechanics--XXI

Last Lesson's Answers

91. The area of the piston equals

$$0.7854 \times 9^2 = 63.62 \text{ sq.in.},$$

and the total pressure on the piston is equal to

$$63.62 \times 35 = 2227 \text{ lb.}$$

The length of the stroke is 12 in., or 1 ft., and, since the engine is double acting (that is, the engine takes steam on both sides of the piston), the piston will travel 2 × 1 or 2 ft. in one revolution of the engine; and the work done will equal

$$2227 \times 2 = 4454 \text{ ft.-lb.}$$

Note—In an actual engine test, the mean effective steam pressure will generally be different for the head and the crank ends of the cylinder. On the crank end a correction must be made for the area of the piston rod, which will reduce the effective area of the piston.

92. The work done in one revolution was found to be 4454 ft.-lb., and hence the work done in 250 revolutions will equal

$$250 \times 4454 = 1{,}113{,}500 \text{ ft.-lb.}$$

Since this work was done in 1 min., the horsepower will be

$$hp. = \frac{1{,}113{,}500}{33{,}000} = 33.7+$$

93. The *prony brake* is a device for absorbing the power delivered by an engine, and consists of a series of wooden blocks fastened to a metal strap which passes around the rim of the wheel on which the brake is placed. By drawing together the ends of the strap, pressure may be put on the blocks, the value of which is determined by resting the end of the brake arm on platform scales. In figuring the horsepower developed, it is essential that the *net load* on the brake be used. This net load is found by subtracting the weight of the brake arm from the total load on the platform scales. For the sake of clearness in finding the brake horsepower, assume the wheel as stationary and consider the weight of 120 lb. as rotating. The distance that the weight would travel in one revolution of the engine would equal the circumference of a circle whose radius is equal to the length of the brake arm. Hence the work done in one revolution will equal (2 × 3.1416 × 5 or) 31.416 ft. times the net weight of 120 lb.

$$31.416 \times 120 = 3770 \text{ ft.-lb. } per\ revolution.$$

(Note—The circumference of a circle equals 2 × 3.1416 × the radius.)

The work done per minute will be

$$3770 \times 250 = 942{,}500 \text{ ft.-lb.}$$

and the developed horsepower will be

$$\frac{942{,}500}{33{,}000} = 28.6- \ hp.$$

94. The output is the brake horsepower or 28.6, and the input is the indicated horsepower; that is, the power developed in the engine cylinder. (Note—The term indicated horsepower is used because the average steam pressure is found from a diagram taken with an indicator.)

$$efficiency = \frac{output}{input} = \frac{28.6}{33.7} = 84.8+ \text{ per cent.}$$

95. The pressure between the blocks and the face of the pulley causes friction to be generated which is dissipated in the form of heat. To keep the pulley cool it is necessary to provide means of conducting away the heat generated. This is usually done by circulating water on the inside of a flanged pulley.

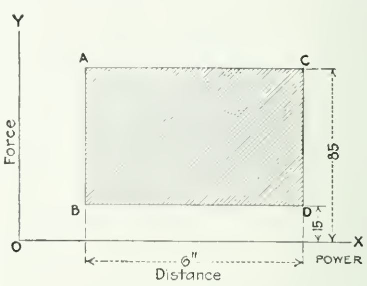


Fig. 67

The brake or developed horsepower can never be greater than the power developed in the cylinder because friction will always be present in various parts of the engine.

Graphical Representation of Work

Work has been defined as the product of a force times a distance. The area of any plane figure is the product of the base times the average height of the figure, and, as work involves but two terms, it may be represented graphically by the area of a figure whose base is proportional to the distance, and whose altitude is equal to the force. Thus, in a direct-acting steam pump, if the pressure on one side of the piston is 85 lb. per sq.in., and on the other side is 15 lb., then the average pressure will equal 70 lb. per sq.in. In Fig. 67 let the distance BD represent the stroke of the pump (assumed as 6 in.) and AB equal the unbalanced steam pressure. Then the area $ACDBA$ will represent the work done by the steam on 1 sq.in. of the piston.

The area

$$ACDBA = AB \times BD = 70 \times 6 = 420 \text{ in.-lb.} = 35 \text{ ft.-lb.}$$

If the area of the piston is 20 sq.in., the total work done per stroke of the pump is

$$20 \times 35 = 700 \text{ ft.-lb.}$$

In like manner the area $ABCDA$ of Fig. 68 represents the work done on 1 sq.in. of the piston of the steam engine provided the distance EF represents the stroke of the engine and the average height of the figure is proportional to the mean effective steam pressure in the engine cylinder. The average height of such a figure as shown may be found by dividing the diagram into 10 or more parts and finding the average height of each separate part, or it may be found more readily by the aid of an instrument called the planimeter.

As a general rule, the mean effective steam pressure will be found from the indicator diagram (Fig. 68) and the indicated horsepower of the engine may be found from the equation,

$$i.\,hp. = \frac{P_e L A N}{33{,}000} \qquad (54)$$

where

P_e = the mean effective steam pressure in pounds per square inch,
L = the length of the stroke in feet,
A = the area of the piston in square inches, and
N = the number of working strokes per minute.

In like manner, the developed or brake horsepower is expressed by the equation

$$b.hp. = \frac{2\pi L N W}{33{,}000} \qquad (55)$$

where

L = the length of the brake arm in feet,
N = the number of revolutions per minute,
W = the net load on the brake in pounds, and
π = 3.1416.

ENERGY

Energy is the capacity of a body for doing work. Any moving body possesses a certain amount of energy which may be transformed into useful work as the body is brought to rest. Thus a stream of water issuing against the bucket of a water wheel has its energy converted into useful work by overcoming the resistance offered by the bucket. The sources of energy are almost unlimited; thus there is energy stored in coal and in all forms of liquid fuels; energy is stored in a coiled spring; the steam in a boiler possesses energy, and the human being has various forms of muscular energy.

Energy may be divided into two general classes,

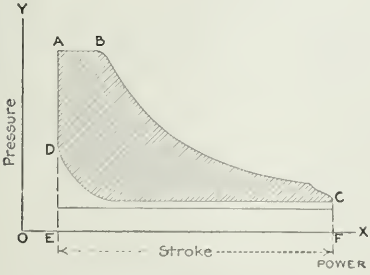


FIG. 68

(1) *Potential*, or energy of position, and

(2) *Kinetic*, or energy of motion.

The water in a reservoir has potential energy due to its location above a certain level. Energy was required to place the water at this level. The amount of potential energy in a body depends upon its weight and the distance of the body above a given reference line or plane. Thus, if an object weighing W pounds be located at a distance of H feet above a given datum plane, then the potential energy of the body will be expressed by the equation,

$$K = W \times H \qquad (56)$$

The unit of energy is the same as that used for work, namely, the foot-pound.

An object possesses kinetic energy by virtue of its velocity. A bullet shot from a rifle is brought to rest by meeting with a body which offers a resistance to the motion of the bullet. The work done by the bullet is equal to the product of the resistance overcome and the distance the bullet penetrated the object, and if frictional losses be neglected the work done by the bullet must equal the kinetic energy of the bullet.

In equation (49) it was shown that the force required to give a definite acceleration to a body weighing W pounds was equal to $\frac{W}{g} \times a$, and from equation (33) the acceleration was found to be $\frac{V^2}{2S}$ therefore, since

$$F = \frac{W}{g} \times a$$

and

$$a = \frac{V^2}{2S}$$

it follows that

$$F = \frac{W}{g} \times \frac{V^2}{2S}$$

or

$$F \times S = \frac{WV^2}{2g} \qquad (57)$$

But $F \times S$ is the product of a force times a distance, and hence represents the work done in bringing the body to rest. The term $\frac{WV^2}{2g}$ represents the energy stored in the body due to its velocity and is therefore the kinetic energy of the body.

Let

K_e = the kinetic energy in foot-pounds,
V = the velocity of the body in feet per second,
W = the weight of the body in pounds, then

$$K_e = \frac{WV^2}{2g} \qquad (58)$$

STUDY QUESTIONS

96. A pump delivers 1000 gal. of water per minute against a pressure of 120 lb. per sq.in. Find the horsepower required.

97. If the efficiency between the steam and water ends of the pump is 70 per cent., find the power required in the steam cylinder.

98. Find the horsepower of an engine that raises 20 tons of coal per hour from a barge to a coal bunker located 150 ft. above the barge, assuming the efficiency between the engine and the load as 75 per cent.

99. A weight of 1000 lb. is used for crushing old castings. If the weight be raised to a distance of 95 ft. above the casting, find the potential energy of the weight.

100. Find the kinetic energy of the weight the instant it touches the casting, assuming that the weight was allowed to fall freely.

Balancing of Internal-Combustion Engines*

By H. F. FULLAGAR

Balancing internal-combustion engines is in general more difficult than with steam engines. The single-acting cylinder and trunk piston generally necessitate wider crank angles than with steam, and if a larger number of cylinders are employed, vibration arises owing to the increased length and flexibility of the crank case or framing. A further difficulty is from the sudden and violent increase of pressure when the charge is fired by a spark, or, when fired by high compression, the compression stroke produces a severe reversal of torque in the crankshaft and reversal of side-thrust between the piston or crosshead and its guide.

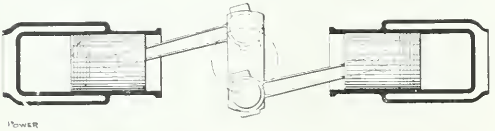


Fig. 1. Opposed Cylinders with Perfect Balance of Mass

BALANCE OF MASS

Balance of the rotating members, the crankshaft and camshaft presents, of course, no theoretical difficulty, provided the crank case is sufficiently rigid to resist the reactions set up.

The inertia forces of the reciprocating parts are of two kinds; primary forces, such as would result if the connecting-rod were of infinite length; and secondary forces, due to the additional motion from the finite length of the connecting-rod. This secondary motion is almost simple harmonic in character, but it has double the frequency. Perfect balance of both the primary and secondary forces can, together, be secured only by placing the connecting-rods on opposite sides of the crankshaft, as in Fig. 1. If, as usual, the crankshaft revolves, the connecting-rods must be attached to opposite cranks, but, if the cylinders revolve both connecting-rods can be attached to a single crank. These constructions, however, have but limited application.

The ordinary motor-car engine with four cylinders operating upon the four-stroke cycle has its cranks in one plane, 180 deg. apart, in order to give reasonable uniformity of impulse. In this case the secondary forces are wholly unbalanced. When the plane of the cranks is horizontal, the connecting-rod has moved the piston to below midstroke by the amount a, Fig. 2, which, if the length of the connecting-rod be four times the crank radius, amounts to one-sixteenth of the stroke. As this displacement occurs twice per revolution and affects all four pistons, the secondary forces set up are equivalent to the inertia of a single piston moving the whole stroke, but acting with double the frequency. With a connecting-rod the length of five cranks, the secondary inertia force is four-fifths of this amount. When two such sets of four cylinders are placed together in the V-type engine, the secondary forces of each set are unbalanced, and their resultant is 40 per cent. greater than either and acts in a horizontal plane.

The secondary forces of the four-cylinder engine, Fig. 2, result from the fact that the common center of gravity of the four pistons, instead of being stationary, as would be the case if the connecting-rods were infinitely long, has a small harmonic motion of double frequency. It can, therefore, be balanced by reciprocating or rotating balance-weights, driven at twice the frequency of the main piston. One method is to gear a pair of wheels carrying balance-weights to the main crankshaft, which drives them at double its speed. As the wheels rotate in opposite directions, the components of the centrifugal forces of the weights always balance themselves in the plane through the axis of the wheels, but have a vertical component which balances the secondary inertia forces. This method, however, involves calling into play two otherwise useless forces, with some addition to the weight and number of parts.

With four cylinders operating upon the two-stroke cycle, the cranks can be placed at right angles instead of at 180 deg., and it is then possible to secure complete balance of both primary and secondary forces, with the exception of a couple produced by the secondary forces in the plane of the cylinders and crankshaft, which tends to rock the engine in a fore-and-aft direction. This couple can usually be neglected in practical application. Engines with five and six cylinders in line, with either cycle, can be perfectly balanced as to the primary, and almost perfectly as to the secondary inertia forces.

To sum up, therefore, the only engine constructions in common use in which balance of mass is completely, or almost completely, secured by the neutralization of the primary and secondary inertia forces, are the engine with rotating cylinders, the engine with five or six cylinders in line, and the four-cylinder, two-stroke-cycle engine with cranks at right angles. All these engines will be without vibration when driven by an external source, provided the crank case or framing is itself perfectly rigid. In practice, it is not always possible, if the engine is long, to obtain sufficient rigidity. With the light motor-car type, even if the crank case be sufficiently rigid, it is difficult when the crankshaft is long to make it so stiff that the engine will not tend to vibrate relative to its flywheel, whose mass-center remains almost stationary.

BALANCE OF IMPULSE

Balance of mass is insufficient in itself to produce a vibrationless engine, because it takes no account of the violently fluctuating pressures in the cylinders, and the consequent strains in the crankshaft and engine framing. To secure freedom from vibration, it is necessary so to arrange the cylinders in relation to the crankshaft that strains in the frame are either eliminated or so balance each other as to have no tendency to shift the center of gravity of the engine relative to its crankshaft and point of support.

If the cylinders, Fig. 1, are arranged in line and fire simultaneously with exactly equal charges, there will be no tendency for the engine to move except, of course, to rotate around the crankshaft. The Junkers engine obtains this equality of impulse, but is unbalanced as to the secondary mass forces. The three cranks of each cylinder receive simultaneous impulses once only per revolution. The crankshaft of the two-cylinder engine, therefore, receives virtually one impulse for every half-revolution. It will be seen, moreover, that in this, as in all single-acting engines, the pressures on the pistons during the compression and explosion strokes twist the crankshaft first backward and then forward, producing a severe condition of stress, while the reaction of the crossheads on their guides also alternate in sign with each stroke.

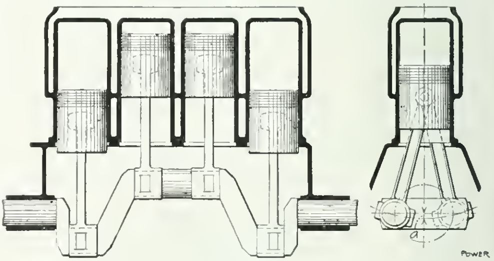


Fig. 2. Ordinary Four-Cylinder Engine; Secondary Forces Unbalanced

If, however, a second pair of cylinders, each with a pair of pistons, be arranged tandem on the top of the first two each tandem line is then double-acting and the cranks of the two sets can consequently be placed at right angles, when balance of impulse will be obtained with primary and secondary mass balance, except only as regards the rocking secondary couple in the principal plane of the engine. The torque transmitted to the crankshaft and the reactions of the crossheads on their guides will then also be in one direction only. This arrangement, however, involves great height and a large number of parts, together with an expensive form of crankshaft, and the same results are obtained more simply, and without these objections in the author's arrangement, Fig. 3.

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*From a paper presented at the July meeting of the Institution of Mechanical Engineers in Paris.

In this, two open-ended cylinders, each with a pair of opposed pistons, are placed closely together side by side, and the upper piston of one cylinder is connected to the lower piston of the other by a pair of external oblique tie-rods, as shown, the piston A to the piston D, and the piston C to the piston B. An explosion between A and B drives B down and A up, drawing up D by the oblique rods and giving two equal and opposite impulses to the two cranks. In separating, the pistons A and B draw together the pistons C and D, compressing the charge between them. The engine operates upon the two-stroke cycle, the pistons at the ends of their stroke uncovering the inlet and exhaust ports, as in the original Oechelhäuser arrangement.

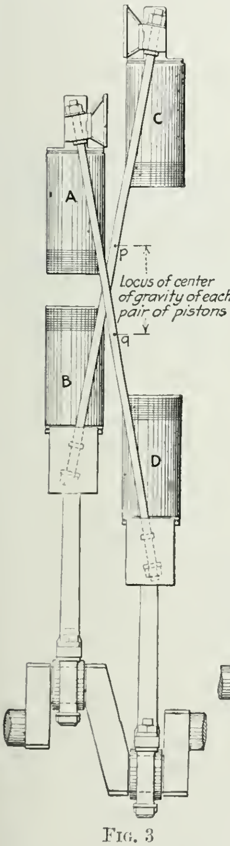

Fig. 3

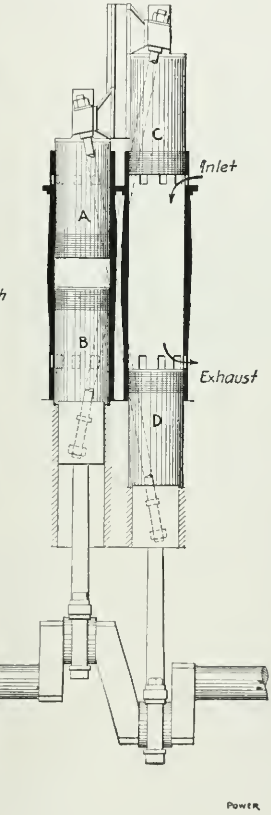

Fig. 4

Fig. 3. Showing Complete Primary Balance. Fig. 4. Fullagar Engine with Primary and Secondary Balance of Mass, and Balance of Impulse if Made with Four Cylinders

The complete engine has two such pairs of cylinders and a second pair of cranks at right angles to the first. The explosions in the four cylinders, acting upon the eight pistons, produce eight impulses per revolution which are transmitted to the crankshaft in equal pairs. The vertical forces at all times balance each other, and, as in the Junkers engine, are not transmitted through the engine frame.

On referring to Fig. 4, it will be seen that the pistons of each pair are rigidly joined together and form one moving part The center of gravity of the pistons A and D (Fig. 3) is at a point q, and travels up and down on the line pq, while the center of gravity of the other pair of connected pistons C and B is at the point p and travels up and down the same line. Thus the primary forces are perfectly balanced.

Secondary forces result from the fact that the common center of gravity of all four pistons and their connecting-rods oscillates on the line pq. This force is, however, balanced by the corresponding force in the other pair of cylinders which oscillate in the opposite phase, and as the two pairs of cylinders are brought closely together, the secondary couple, which alone remains, is much smaller than in the Junkers arrangement. With a six-cylinder engine even this secondary couple is entirely obliterated.

A 500-hp. engine of this type has been in operation about a year. At first sight, it might be supposed that the oblique rods would involve considerable friction, but the angle of the rods is less than the maximum angle of the connecting-rods, and this friction is actually less than would be the case if each of the eight pistons had its own crank and connecting-rod. The mechanical efficiency, excluding the air and gas pumps, is over 90 per cent.

Utility Experts Appointed

Philadelphia's convention next November of mayors and municipal officials throughout the country for the establishment of a Utilities Bureau to represent the cities of the nation in working out their relations with public utility corporations, promises to be one of the most notable conventions for municipal advancement ever held in the United States. With the approval of his coworkers, including the mayors of New York, Chicago, Cleveland and other cities, Mayor Blankenburg of Philadelphia appointed the following preliminary committee of experts to work out the details of the convention:

Louis D. Brandeis, lawyer, Boston; counsel for Interstate Commerce Commission on application of Eastern railroads for 5 per cent. increase; Charles R. VanHise, president, University of Wisconsin, Madison, Wis.; S. S. Fels, manufacturer, Philadelphia; Frederick W. Taylor, consulting engineer, Philadelphia, past president of the American Society of Mechanical Engineers, leader in scientific management movement; Frederick A. Cleveland, director of the New York Bureau of Municipal Research, formerly chairman of the President's Commission on Economy and Efficiency; Leo S. Rowe, professor of political science, University of Pennsylvania, president of the American Academy of Political and Social Science; Charles F. Jenkins, publisher, Philadelphia, proprietor of the "Farm Journal"; Felix Frankfurter, administrator and lawyer, Cambridge, Mass., professor of law, Harvard University, chief legal adviser of the Colonial Administration of the United States under Presidents Roosevelt, Taft and Wilson, had important part in trials of Morse, Heinze and the Sugar Trust.

Mayor Blankenburg, it was said, will increase the membership by three or more experts. The Utilities Bureau, Director Cooke said, is now ready for business. Such temporary administrative staff as may be needed to carry on its work between now and next November, when the conference of mayors will be held here, has now been provided. In addition to gathering general data, other cities will be advised, he said, and assisted in making such application of its researches to local conditions as shall be most likely to secure favorable consideration at the hands of Public Service Commissions and other like bodies.

Coal Breaks All Records

The production of coal in the United States has again broken all previous records, the output for 1913 being 570,048,125 short tons, which is considerably more than double the production of 1900 and more than eight times the production of 1880, according to a statement just issued by the United States Geological Survey, from figures compiled by Edward W. Parker, coal statistician. The value of the coal mined in 1913 is given as $760,488,785.

Compared with the previous year the output for 1913 shows an increase of 35,581,545 tons, or nearly 7 per cent. The increased activity indicated by these figures was well distributed throughout the 29 coal-producing States, 23 of which showed increases and only 6 decreased production, the decrease in one of these—Colorado—being due solely to labor trouble. Of those showing increase, 12 made record yields, and Pennsylvania, the leading coal State, broke records in both bituminous and anthracite production. The States which broke all former records in coal production were Alabama, Illinois, Kentucky, Montana, New Mexico, Ohio, Oklahoma, Pennsylvania, Texas, Utah, Virginia and West Virginia. The largest increase in the production of bituminous coal was in Pennsylvania, where 11,915,729 tons was added to the output of 1912. West Virginia showed the second largest gain, 4,522,295 tons, and Kentucky the third largest gain, 3,126,079 tons, which was also the largest percentage of increase, amounting to 19 per cent., of all the important coal-producing States. Indiana was fourth, Illinois fifth, Ohio sixth, and Alabama seventh. While the total increase was very large as figured in tons, the percentage is what may be considered normal and indicative of healthy industrial activity throughout the country.

ENGINEERING AFFAIRS

On the evening of July 21 the University of Pittsburg gave a dinner for the professors of engineering of the different colleges of the country who are in Pittsburgh for the summer course given by the Westinghouse Electric & Manufacturing Co. An address by Dean F. L. Bishop, of the School of Engineering of the University of Pittsburgh, had the topic, "The Pittsburgh Idea" in education. Each of the visiting professors was called upon to give a short boost to his own particular college. Fourteen different colleges and universities were represented.

PERSONALS

Hubert E. Collins, consulting and operating engineer, has opened an office at 132 Boyce Ave., Utica.

William Schatz is now representing the Platt & Washburn Refining Company, 11 Broadway, New York City.

R. A. Anderson has been appointed chief engineer of the power station of the Portsmouth (N H.) Electric Railway, to succeed John Kirk.

H. E. Harley has been appointed chief engineer of the power station of the Jacksonville (Fla.) Traction Co., to succeed F. D. Barry.

Lester Boring, formerly chief plant engineer, has been appointed superintendent of the municipal electric and water plant at Tipton, Ind.

W. B. Gregory was recently appointed engineer of the power station of the Connecticut Co. at Berlin, Conn., on the Middletown branch, to succeed S. Sargeant.

W. R. Haynie, who has been for over two years United States representative for Usines Carels Freres, of Ghent, Belgium, having contracted with the Nordberg Manufacturing Co. for the exclusive manufacturing and selling rights on Carels-Diesel engines in the United States, is now the special Diesel representative of the Nordberg Manufacturing Co., with offices at 30 Church Street, N. Y.

Edward Gray for some time mechanical engineer of the Ford Motor Co. and well known in gas power circles, especially in connection with the design and installation of the big Ford gas engine, has severed his connections with that company and will for the present devote his time to some personal projects which he has now under way in Detroit. His successor at the Ford Co. will be William B. Mayo, formerly secretary and general manager of the Hooven, Owens, Rentschler Co.

Edward Schildhauer resigned as electrical and mechanical engineer on July 13 from the Panama Canal service. He entered the service as electrical and mechanical engineer in 1906. He has been occupied principally with the designing, manufacturing, and installation, under the direction of Col. H. F. Hodges, engineer of maintenance, of the machinery and electrical equipment for the operation of the Canal locks, spillways and power plants, including the new hydroelectric station at Gatun, the substations at Gatun, Cristobal, Miraflores and Balboa, and with the new transisthmian transmission line. He invented and patented the bull wheel which operates the lock gates, and the system of electric towing locomotives for handling ships in the locks. Another novel device manufactured from designs prepared in his office, is the system of remote control by which every part of the lock operating machinery is manipulated from a central station or control house, and where, with the aid of a reproduction of the lock and its operating features in miniature, every movement is registered before the eyes of the operator. Mr. Schildhauer was born in New Holstein, Wis., entered the University of Wisconsin at the age of 21, and was graduated in 1897, with the degree of bachelor of science in electrical engineering. The master's degree was conferred in 1911. He was engaged in electric railway construction until 1898, when he entered the employ of the Chicago Edison Co. and was with this company at the time of his appointment to the Canal service. He is president of the Panama Section of the American Institute of Electrical Engineers, chairman of the Canal Zone Chapter of the American National Red Cross Society and a member of various societies in the United States, including the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the National Electric Light Association and the American Electro-Chemical Society. He will make his headquarters at the Engineers' Club, New York City. He was given a farewell reception by the Tivoli Club July 11 and by the University Club on July 15.

OBITUARY

EDWARD B. DENNY

On July 12, Edward B. Denny, past president of the National Association of Master Steam and Hot Water Fitters, died at his home in Newark, N. J. His death was due to heart disease superinduced by acute indigestion.

Mr. Denny received a common-school education and, after several years' employment in other lines, took up the business of manufacturing gas machines in 1874. He invented a portable gasolene gas machine, and about the same time he enlarged his field of operations by taking up the steam and hot water heating business, in which line he has been engaged ever since in partnership with brothers.

He was one of five children whose average at the time of his death was over 60 years.

Mr. Denny was a member of the American Society of Heating and Ventilating Engineers; National Association of Master Steam and Hot Water Fitters; New Jersey State Association of Master Steam and Hot Water Fitters; Newark Association of Master Steam and Hot Water Fitters; Newark Y. M. C. A.; St. John's Lodge, No. 1, F. & A. M., Newark, N. J.; and Empire State Society of the Sons of the American Revolution.

The Rev. Dr. John McDowell of Park Presbyterian Church conducted the funeral services at the home of John W. Denny, Newark, N. J. Interment was on Thursday morning, July 16, at Linden Cemetery, near Elizabeth, N. J.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Holyoke Street Ry. Co., Holyoke, Mass., has purchased a site on Pleasant St., in Mill Valley, on which to build a power house to supply energy for the Sunderland and Amherst division. Louis D. Pelissier is Gen. Mgr.

The Narragansett Electric Lighting Co., Providence, R. I., contemplates rebuilding the turbine room of its generating station some time within the next few months. W. T. Oviatt is Gen. Supt.

The power house at the plant of the Farist Steel Co., 137 East Main St., Bridgeport, Conn., will be rebuilt. The building will be of brick and steel, 55x78 ft.

Bids will be received until 3 p.m., Aug. 17, by the State Hospital Commission, Albany, N. Y., for the construction of a power house, boilers, equipment and steam conduit, plumbing, electric equipment and underground electric conduit at the Long Island State Hospital, Brooklyn, N. Y. J. H. Hanify is Secy. State Hospital Comn.

The Lebanon Power & Lighting Co., Canaan, N. Y., plans to build a power plant in Canaan, on the outlet of Queechy Lake, to supply energy to Canaan, New Lebanon, Lebanon Springs and West Lebanon. The equipment of the plant will include: One 225-hp. Atlas boiler, one 175-hp. Corliss engine, two Leffel waterwheels (135 hp.), one 150-kw. General Electric and one 125-kw. Fort Wayne generator (each three-phase, 60-cycle, 2300-volts), General Electric switchboard equipment and Duncan transformers. O. C. Schmoyer, Greenville, Penn., is Engr.-in-Charge.

It is reported that the power plant for the Onondaga County Tuberculosis Sanitarium, Syracuse, N. Y., will cost about $35,000. The equipment will include boilers, engines, heating apparatus, pumps, telephone switchboard, etc.

The City Council has authorized Samuel J. Mason, City Engr., to prepare an estimate of the cost of installing a municipal electric-light plant in Perth Amboy, N. J.

Bids are being received by John T. Windrim, Arch., Commonwealth Bldg., Philadelphia, for the construction of a one-story brick and concrete power house at 20th St. and Oregon Ave., Philadelphia, Penn., for the Stephen Girard Estate. It will be 67x88 ft.

POWER

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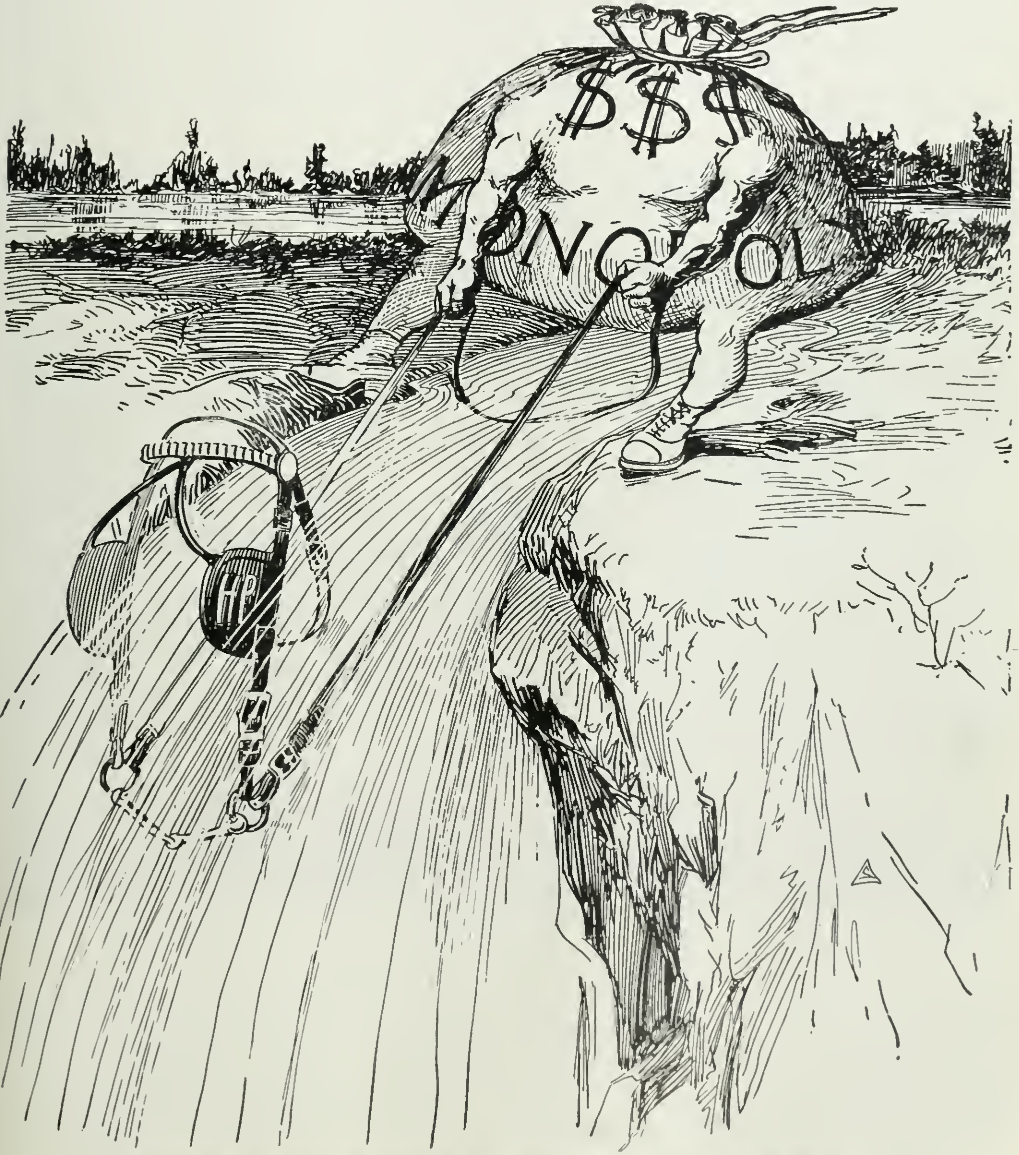

SHALL MONOPOLY HOLD THE REINS?

Condenser and Cooling Tower for Mixed-Pressure Turbine

By George F. Pond*

SYNOPSIS—The condensing and natural-draft cooling-tower equipment installed at a silk mill forms an efficient unit for installation in connection with a mixed-pressure turbine. The plant is a typical example of what can be done. There are also included some test figures showing the vacuum maintained under adverse atmospheric conditions of temperature and humidity.

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Plants built primarily to generate power, as central stations, are located along a water front to obtain ample cooling water for the condensers, but many mills, factories and industrial plants must be constructed where cooling water is scarce or unavailable. For this reason, noncondensing engines have been installed usually and the loss in the steam escaping to the atmosphere has been considered as unavoidable.

The lack of condensing water has also been a drawback to the use of mixed-pressure and low-pressure turbines in such plants, although by their use under suitable conditions the power capacity can be almost doubled for the same coal consumption and boiler-house equipment. The savings attainable are so great that it pays to install apparatus for artificially recooling the condensing water; the only problem is in selecting a recooler which is as nearly equivalent as possible to a natural supply of cold water.

There are many devices for recooling water, including large artificial ponds, spray nozzles, open cooling towers, closed cooling towers of the forced-draft type, and closed cooling towers of the natural-draft type. Inclosed cooling towers are an efficient means of recooling water and the natural-draft tower gives excellent results where the ground area available for it is sufficient.

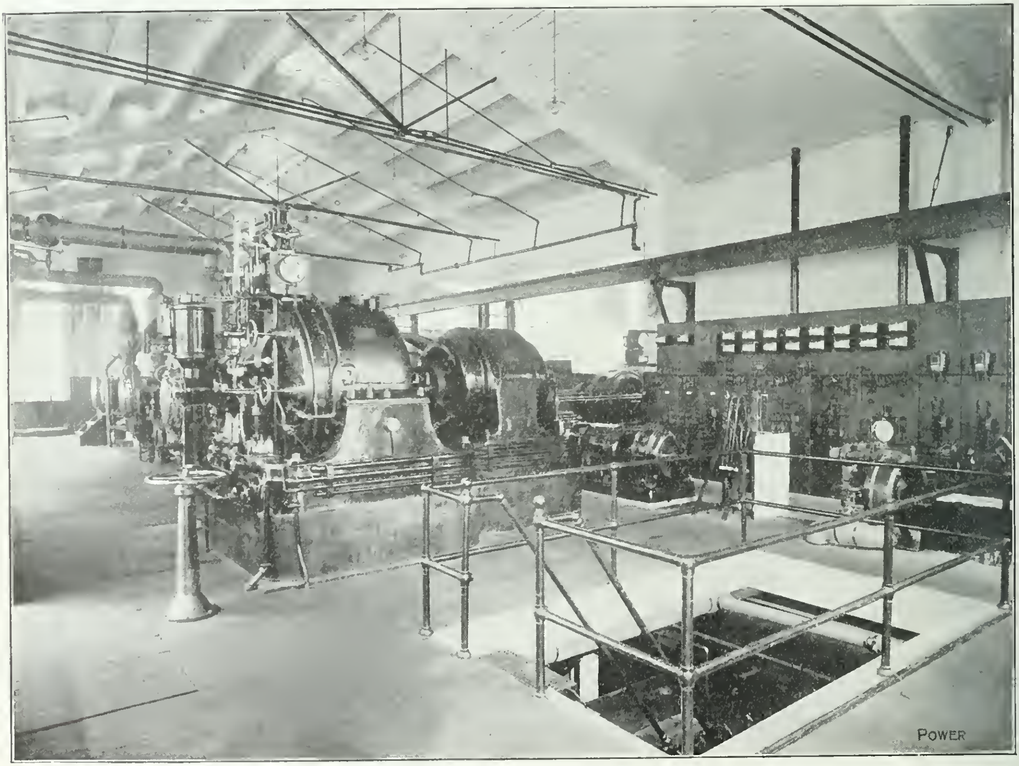

Fig. 1. Turbine and Engine Units in Engine Room of the Sauquoit Silk Mfg. Co.

At the plant of the Sauquoit Silk Mfg. Co., Scranton, Penn., there is a mixed-pressure turbine, condensing plant and a natural-draft, chimney-type inclosed cooling tower.

The steam turbine is a 500-kw. mixed-pressure, 3600-

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*Philadelphia office manager, the Wheeler Condenser & Engineering Co.

r.p.m. unit, driving a 60-cycle alternator and is supplied with exhaust steam from three 300-hp., cross-compound engines, seen behind the turbine, Fig. 1. Any deficiency in the exhaust of the engines is made up automatically by the live steam admitted to a high-pressure stage of the turbine through which it expands before joining the low-pressure steam.

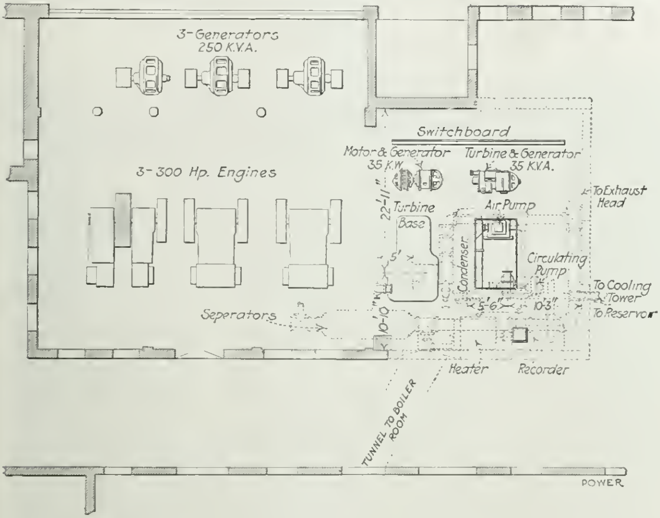

Fig. 2. Plan View of Old and New Engine Room

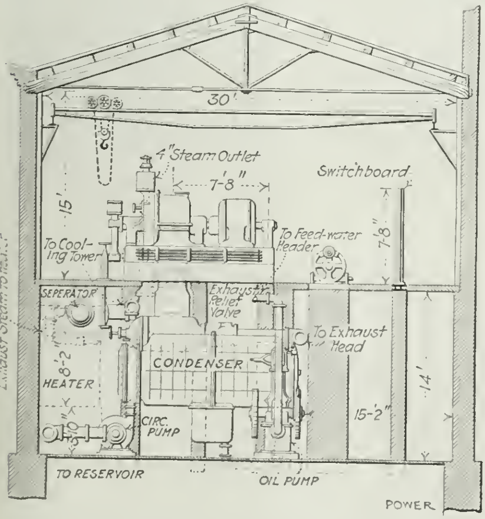

Fig. 3. Cross-Section through New Engine Room

The condensing equipment comprises a surface condenser, a motor-driven circulating pump, an air pump and a natural-draft cooling tower. The condenser is guaranteed to condense 20,000 lb. of steam per hour and maintain a 27-in. vacuum when the air is at 75 deg. temperature and 70 per cent. humidity. Fig. 2 shows the general arrangement of turbine, condenser and cooling tower.

The atmospheric conditions of 75 deg. of temperature and 70 per cent. of humidity are the average for July and August, the least faverable months in the year, while the average annual conditions are about 55 deg. of temperature and 70 per cent. of humidity. The vacuum at the exhaust of the turbines averages 27 in. during the hottest months, and at the other 10 months, between 27 and 28 in., going even slightly above 28 in. at times of low temperature and humidity.

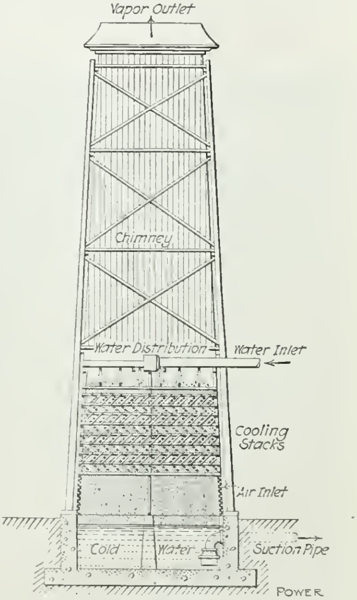

Fig. 4. Section through Natural-Draft Cooling Tower

The condenser, Fig. 5, is of the rectangular-shell design. The circulating water makes two passes through it and is heated to within a few degrees of the exhaust-steam temperature, as shown by the test figures given.

The condenser and pumps are in the basement beneath the turbine, the pumps being shown in Figs. 3 and 6, in which the air pump is in the front and the motor-driven circulating pump in the rear. The air pump is of the single, steam-driven type, operating at 95 r.p.m. The air-discharge vent is shown, also the discharge pipe for the condensate, which is delivered to a height of 12 ft. without the aid of a separate pump. The motor-driven circulating pump has a capacity of about 1600 gal. per min., the water being drawn from the sump of the cooling tower, pumped through the tubes of the condenser and delivered to the distributing troughs of the tower at an elevation of about 20 feet.

Fig. 7 is an exterior view of the tower. Its base is square in section and the chimney is octagonal, and has a pleasing appearance. The height of the chimney above the foundations is 70 ft., giving ample natural draft and making fans unnecessary. When once installed, the tower requires no attendance and consumes no power.

Fig. 4 shows the tower in section and illustrates the arrangement of the zigzag cooling stacks and the distributing system; the latter consists of wooden troughs from which the water falls through iron spouts to splash plates, which throw the water out in all directions and distribute it evenly over the whole area of the filling.

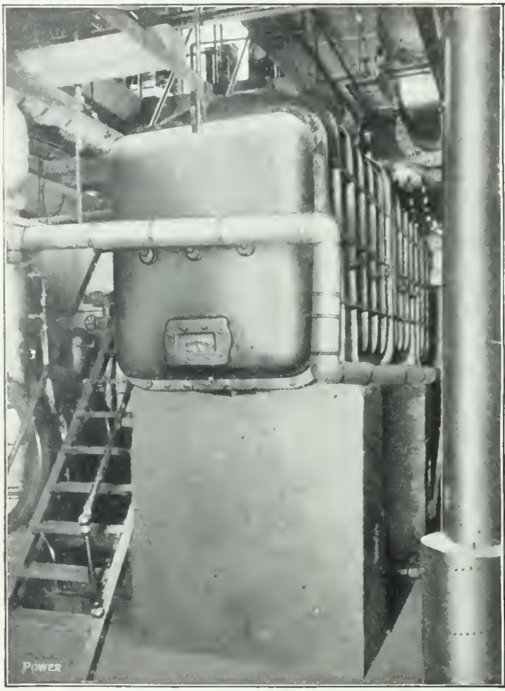

Fig. 5. Condenser and Concrete Foundation

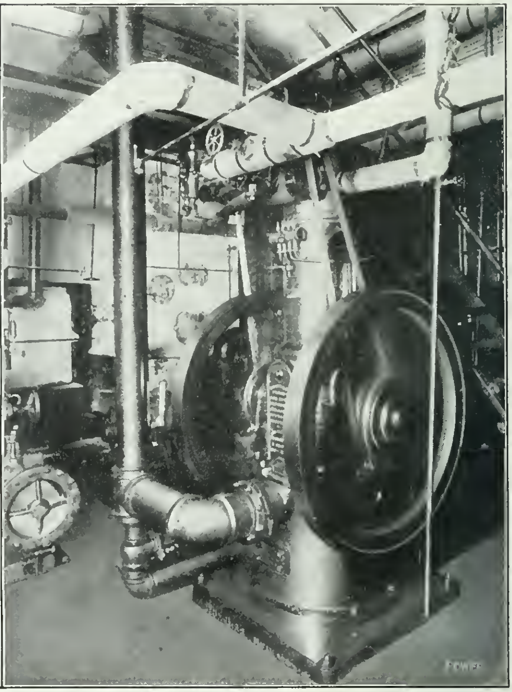

Fig. 6. Air Pump and Piping

The water is cooled in two ways: first, by the evaporation of a small percentage which abstracts approximately 1000 B.t.u. (cooling 40 lb. 25 deg.) for each pound of water evaporated and secondly, by the heat taken up by the warming of the air. This latter is only a small percentage of the cooling, by far the greatest part being due to evaporation.

It is of interest to compare the quantity of water lost and the make-up required due to this evaporation in the tower, with the loss of water by noncondensing engines. If all the cooling is by evaporation, then approximately 1 lb. has to be evaporated to dissipate 1000 B.t.u., which is equal to the heat given up to the water by the condensation of 1 lb. of exhaust steam. Actually, the increase in the temperature of the air absorbs about 20 per cent. of the heat in the tower so that the loss of water is 80 per cent. of the condensation. Without the low-pressure turbine, all of the steam would be exhausted to the atmosphere and only half the power generated or for the same power, twice the steam would be exhausted, representing more than twice the loss of water per kilowatt-hour. Where city water must be purchased at meter rates, this saving in water alone is a considerable item.

The following tables show the results obtained in August, 1913, with loads of 450 and 500 kw. on the turbine running with exhaust steam, corresponding to an engine load of 400 kw. With atmospheric conditions of 74 deg. temperature and 86 per cent. humidity and a load of 450 kilowatts, the vacuum corrected to a 30-in. barometer was 27.55, and at 500 kilowatts and the same atmospheric conditions, the vacuum was 27.4:

TEST NO. 1
Aug. 6, 1913

Turbine load	450 kw.
Temperature exhaust steam entering condenser	108°
Temperature circulating water, in	84°
Temperature circulating water, out	104°
Temperature condensate	90°
Temperature atmosphere	74°
Per cent. humidity	86
Per cent humidity corrected to 30-in. barometer	27.55 in.
Vacuum per cent. humidity corrected to 30-in. barometer	27.55 in.

TEST NO. 2

Load on 500-kw. turbine	500 kw.
Temperature exhaust steam entering condenser	112°
Temperature circulating water, in	86°
Temperature circulating water, out	107°
Temperature condensate	97°
Temperature atmosphere	74°
Per cent. humidity	86
Vacuum corrected to 30-in. barometer	27.4 in.

The atmospheric conditions are considerably less favorable than the guarantee, while the vacuum is almost half an inch higher. This high vacuum is probably explained in part by the margin of capacity of the apparatus; also, because the turbine was not operating on low-pressure steam and the amount of steam condensed at 500 kilowatts was somewhat less than the rated 20,000 lb.

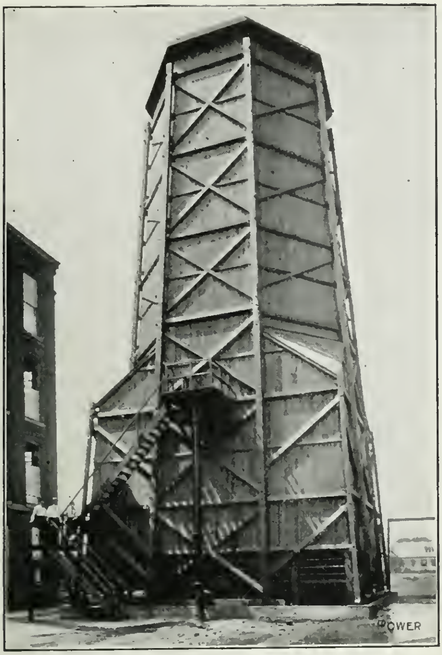

Fig. 7. Natural-Draft Cooling Tower

This equipment has been used for about a year. The operating records show that during the winter months the vacuum is about 28 in., and the average vacuum throughout the year is 27½ in. The increase in plant economy due to the installation of the mixed-pressure turbine, the cooling tower and the condensing equipment amounts to a large sum per year; it is estimated that the entire equipment will pay for itself in five years.

The plant was designed and installed by the Sauquoit Silk Mfg. Co., under the direct supervision of their mechanical superintendent, L. G. Schlehner.

A Gas-Pumping Station

By D. O. Barrett

About three miles southeast of the city of Mansfield, Ohio, is located one of the gas-pumping stations of the Medine Gas & Fuel Co. An exterior view of the plant is shown in Fig. 1. The large central building houses the main pumping engines, while the auxiliaries are located in the building at the left. The water tank has a capacity of 30,000 gal. All the buildings are of steel construction throughout, with corrugated iron covering.

At present there are two main units, each rated at 475 hp., provision having been made for the installation of a third unit, which will be put in shortly. These engines were built by the C. & G. Cooper Co., and are 21½-in. bore by 36-in. stroke. At the flywheel end is placed the 15x36-in. Hall single-stage compressor supplied with an 8-in. suction and a 6-in. discharge pipe, the compressor cylinder being operated from the crosshead.

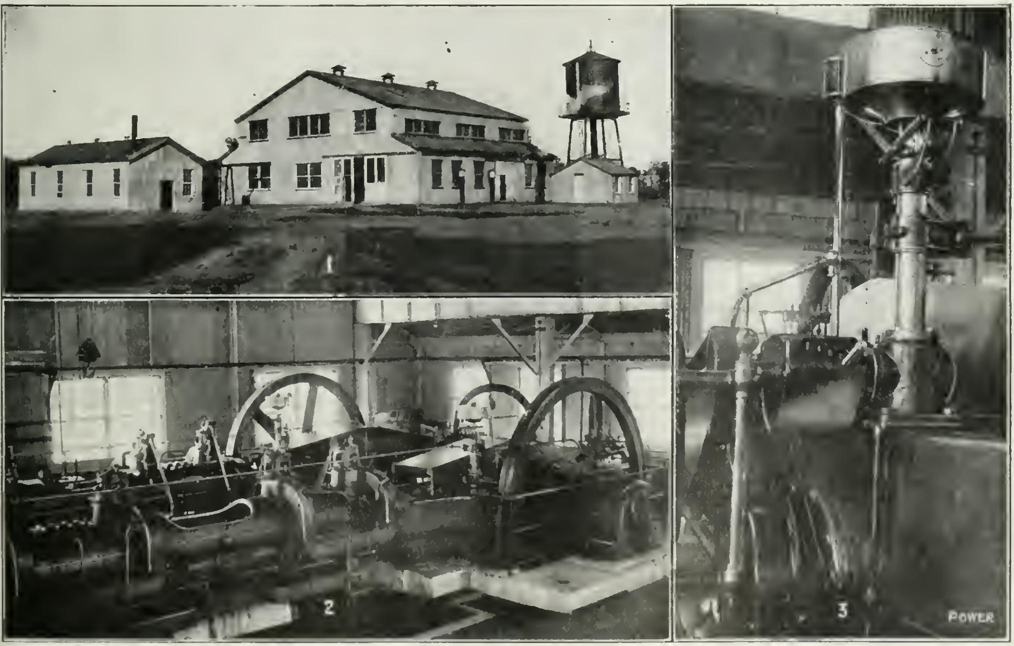

Fig. 1. Pumping Station. Fig. 2. Gas-Engine Pumping Units. Fig. 3. Governor Showing Speed-Changing Device

Since it is not always convenient nor economical to operate at full speed, due to the frequently occurring light loads, one of the engines was fitted with a speed-changing device, shown in Fig. 3. This is similar to the feed box on a lathe, the lever being provided with five positions, giving speeds of 60, 70, 80, 100 and 125 r.p.m., the latter being the rated speed of the engine. Changes may be made while the engine is running, care being taken to throw the gears in quickly and but one step at a time. The lever projecting from the gear case is arranged with a spring handle and carries a sliding frame in which is located an idler gear. The Richardson oiling system is used, the overflow cup being shown back of the governor.

Just back of the power house is a large pond supplied from an artesian well. In the pond are laid sixteen 4-in. gas lines about 200 ft. long, through which the gas is transmitted before entering the mains. This quite effectively cools the gas. The pipes are attached to headers in such a manner that any pipe may be cut out should it become necessary at any time to make repairs.

The auxiliaries consist of two 30-hp. Superior gas engines connected to a line-shaft from which are driven a two-stage air compressor, two 300-gal. centrifugal pumps and a 6-kw. generator connected to a 20-cell storage-battery plant. A boiler is also provided for steam heating.

The discharge pressure into the gas line varies from 175 to 200 lb., while the suction pressure is extremely variable, depending entirely upon the weather, which regulates the amount of gas being pumped. The engineers work in 12-hr. shifts, each being provided with one helper.

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Hand-Fired Settings for Heating Boilers*

By Osborn Monnett†

SYNOPSIS—Description of settings designed for smokeless operation, with full instructions on starting, firing, cleaning and banking.

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In previous articles, the discussion on hand-fired furnaces applied particularly to rates of combustion of from 15 to 30 lb. per sq.ft. of grate surface per hour; in other words, to ordinary power loads. The double-arch, bridge wall setting is not so well adapted to rates of combustion lower than this, although the McMillan and twin fire-arch furnaces may be used either for low or for high rates of combustion, owing to the projection of the refractory material forward of the bridge-wall, this having the effect of maintaining a high-temperature zone with a slow fire.

A setting known as the Department No. 7 has been worked out for rates of combustion below 15 lb. per sq.ft. of grate surface per hour. This setting, shown in the accompanying illustration, consists of an arch sprung over the grate, with a deflection arch behind the bridge-wall, the two being connected with a single-span arch over the bridge-wall. The brickwork over the grates has the effect of creating and maintaining a high-temperature zone which would not be possible when the rate of combustion was low unless this refractory material was provided. It also interposes an extended flame travel at high temperature and a good deflection against the arch in the combustion chamber. On the sizes from 66 in. by 18 ft. up, the deflection arch should be built of two spans with a 13-in. pier in the center, as this kind of construction lasts longer and provides better deflection. The illustration and the table give the necessary dimensions for this type of setting for all commercial sizes of horizontal, return-tubular boilers.

DIMENSION SHEET FOR NO. 7 FURNACE

All dimensions in inches, except column B, which is in feet.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
48	14-0	34	20	48	48	24	15	48½	4	16½	54	16	18	20	27	21½	18½	15	8	9	8	4½	6	9
48	16-0	34	20	54	48	24	15	53	4½	15½	56	16	18	22	30	23	20	16½	8	9	8	4½	6	9
54	14-0	36	22	48	54	24	18	48½	4	18½	54	16	18	20	27	21½	18	15	9	9	9	4½	7	9
54	16-0	36	22	54	54	24	18	53	4½	17½	57	17	18	22	30	23	19½	16½	9	9	9	4½	7	9
60	16-0	40	22	60	60	26	18	63	5	15½	64½	18	22½	24	33½	29½	25½	18½	10	9	10	9	7½	9
60	18-0	40	22	66	60	26	18	66½	5½	14½	66½	18	22½	26	35½	31	27	20	10	9	10	9	7½	9
66	16-0	40	24	60	66	28	19	64	5	15	64½	18	22½	24	34	30	25	19	11	9	11	9	8½	9
66	18-0	40	24	66	66	28	18	68½	5½	14	68½	20	22½	26	37	31½	26½	20½	11	9	11	9	8½	9
72	16-0	42	24	66	72	30	20	73	5½	16	74½	22	22½	30	41½	31½	27	20½	4	9	12	9	9	9*
72	18-0	42	24	72	72	30	20	79	6	14½	78½	24	22½	32	46	33	28½	22	4	9	12	9	9	9*

Note—First grade of firebrick to be used throughout with the exception of the combustion-chamber floor and the side walls of the chamber back from a point 1 ft. behind the rear face of the deflection arch.

Fire doors must provide for special air admission of an area equal to 4 sq.in. for each square foot of grate surface.

Make damper openings equal to 25% excess of tube area.

Dimensions in the above table apply only for the ordinary conditions, and are subject to revision for unusual conditions.

*Deflection arch built with a 13½x13½-in. center pier.

Firing a No. 7 Setting

The methods of starting, cleaning and banking the fire are the same as given in the last article for power boilers. In operation, however, the coking method should be used. This consists of heavily charging the front part of the furnace with coal, allowing it to ignite and coke, pushing back the coked portion to expose the fresh coal near the dead plate, and finally pushing back the entire fuel bed and refilling the front part of the furnace with fresh coal. This should be done by the alternate method, using the panel doors freely. As the boiler operates at low pressure there will be no steam jets available, so that smoke suppression must be accomplished entirely by the use of the panel doors. When the coking method is used there need not be much trouble from smoke, as the rate of combustion is such that the volatile does not necessarily have to pass off at a high rate.

In using the alternate system with the coking method of firing, push back one side at a time and fill up with green coal. The next time this side is stoked, the coal on top near the door which is partially coked is pushed back, leaving the unburned green coal underneath to coke on the grate. When this has been coked it is pushed back, the front part of the furnace refilled, and the same operation is repeated.

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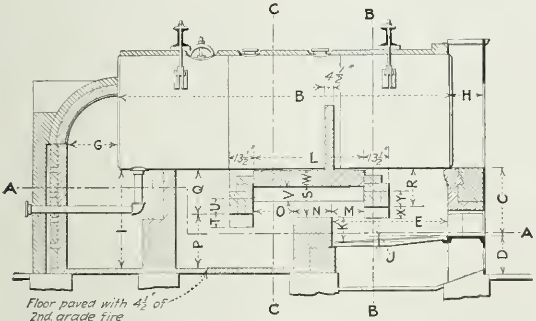
*Copyright, 1914, Osborn Monnett.

†Smoke inspector, city of Chicago.

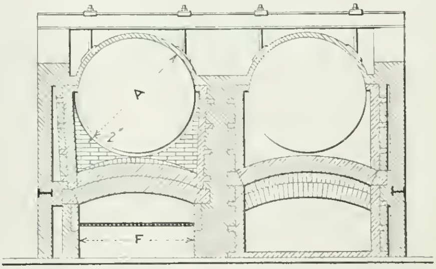
Firebox Boilers

The locomotive firebox has come into general use for heating purposes in buildings where the return-tubular boiler would be too large. Thousands of these boilers are used in flats and residences, only one boiler being installed at each place. It is necessary to use extreme care in firing this type with any kind of coal if smokeless results are to be obtained. In fact, it is practically impossible to use a coal with the volatile content higher than 20 per cent. and expect satisfactory smoke conditions. For this reason, this type is limited to the use of semi-bituminous coal. With intelligent care, this coal can be fired in a firebox boiler without making dense smoke. The following instructions apply specifically to this kind of boiler and should be followed carefully if smoke suppression is an important consideration.



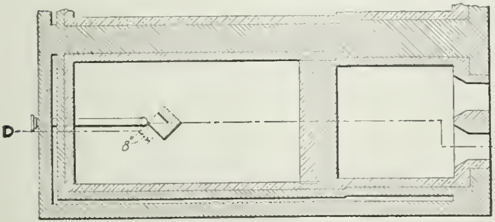
Floor paved with 4½" of 2nd. grade fire brick on edge

LONGITUDINAL SECTION D-D



CROSS-SECTION B-B CROSS-SECTION C-C

Return-Tubular Setting for Low Rates of Combustion



SECTIONAL PLAN A-A

Starting a New Fire—Have the ashpits, grates, tubes and all other accessible parts clean. When starting a fire, always have a large amount of kindling ready for use. This is necessary because the heat from the wood fire must ignite the coal and maintain heat long enough to give the coal a good start.

Open the ashpit doors. This does not mean the panels. Make sure that the damper in the smoke connection is wide open. Put into the firebox, on the bare grates, a layer of coal about 6 in. thick immediately inside of the fire-doors and gradually thinning down to 1 in. at the tube sheet. Place the kindling wood on top of the coal. Sprinkle one scoop of coal over the wood. Light the wood at the front, close the firing doors to within ½ in. of being tight and leave the circular shutters in the doors wide open. The coal will burn from the top down, being ignited from the wood. Any good coal that drops through the grate can be scraped out of the ashpit and used when the fire is under way.

Regular Firing—Push the live coal from the top of the fuel bed at the front of the grates back toward the tubes. Do not push any green coal back, as this will cause smoke. Put a heavy charge of fresh coal on the front of the grates immediately inside the doors. Do not close the fire-doors tight; have them stand open about ½ in. Repeat this operation for each successive firing.

The live coal on the back half of the grates will maintain the required heat and cause the green coal on the front half to give up its gas. This gas will pass over the live coal and be burned before it reaches the tubes. Run the fire so that the fuel bed is always thick, especially just inside the doors. Do not spread the coal over the entire grate as this will cause a great deal of smoke no matter what kind of coal is used.

Cleaning Fires—The time when it is necessary to clean fires will be indicated by the fact that the boiler cannot make steam fast enough to deliver the required heat. Prepare for cleaning by arranging to have a large charge of coked fuel on the grates immediately inside the doors.

Allow the fire on the back half of the grates to burn down slightly. When ready to remove the clinker, close the ashpit doors and the panels in the doors. Pull the clinker from the back half of the grates over the fire in front with as little disturbance as possible of the fuel bed in front. After the clinker is out, shake the grates. Open the ashpit doors, push the live coal from the front so as to cover the rear half of the grates. Put in a large charge of fresh coal immediately inside the firing doors, leaving them open about half an inch and the circular shutters in the doors full open.

Clinker need seldom be removed from the front half of the grates as it does not form there, and the shaking grates will more than likely take care of the ashes. When it is necessary to remove clinker that has found its way to the front half of the grates, wait at least one hour after having cleaned the back half; then push the live coal lying on the front half of the grate on to the back half and pull the clinker out of the front doors. Fire a heavy charge of fresh fuel just inside the fire-doors, leaving the doors cracked as before. Do not close the ashpit doors when cleaning the front portion of the grates.

Banking Fires—Push the live coal from the front on to the back half of the grates. Put a charge of fresh coal on the front of the grates immediately inside of the fire-doors, using considerably more coal than for an ordinary firing. This may mean from 15 to 18 large scoops of coal, depending upon the size of the grate. Leave the damper in the chimney connection wide open. Leave the circular shutters in the fire-doors wide open and close the doors themselves.

Starting Up after a Banked Fire—Shake the grates well; there will be little clinker. Open the ashpit door wide. Break the fire down with a bar and then let it burn for 10, 15 or perhaps 20 min., depending upon the quantity of fuel there is in the firebox. When the regular firing begins, put a large charge of fuel on the front half of the grates immediately inside of the firing-doors after pushing most of the live coal back to the back half of the grates. Do not close the stack damper for any cause. Do not allow the tubes to become dirty. Cleanliness is of great importance in a boiler of this type. Do not fail to clean out the smoke connection between the boiler and the chimney, especially at the beginning of the heating season. Do not leave the clean-out door at the bottom of the chimney open. Do not make openings in the chimney for ventilating purposes. Do not depend on the damper regulator.

⁂

Graphic Air-Compressor Calculations

By F. H. Rosencrants

SYNOPSIS—Charts for determining horsepower required to compress a given quantity of air and the volumetric efficiency of air compressors, with examples in each case to illustrate their use.

⁂

In connection with compressed-air work a common problem is the determination of the power necessary to compress a given volume of air from one pressure (usually that of the atmosphere) to some other higher pressure. It can be shown mathematically that the power absorbed in the cylinder by the air is:

$$hp. = \frac{144\,P_1 V_1}{33{,}000} \times \frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

in which

P_1 = Absolute suction pressure in lb. per sq.in.;
P_2 = Absolute discharge pressure in lb. per sq.in.;
V_1 = Volume of free air compressed per min. in cu.ft.;

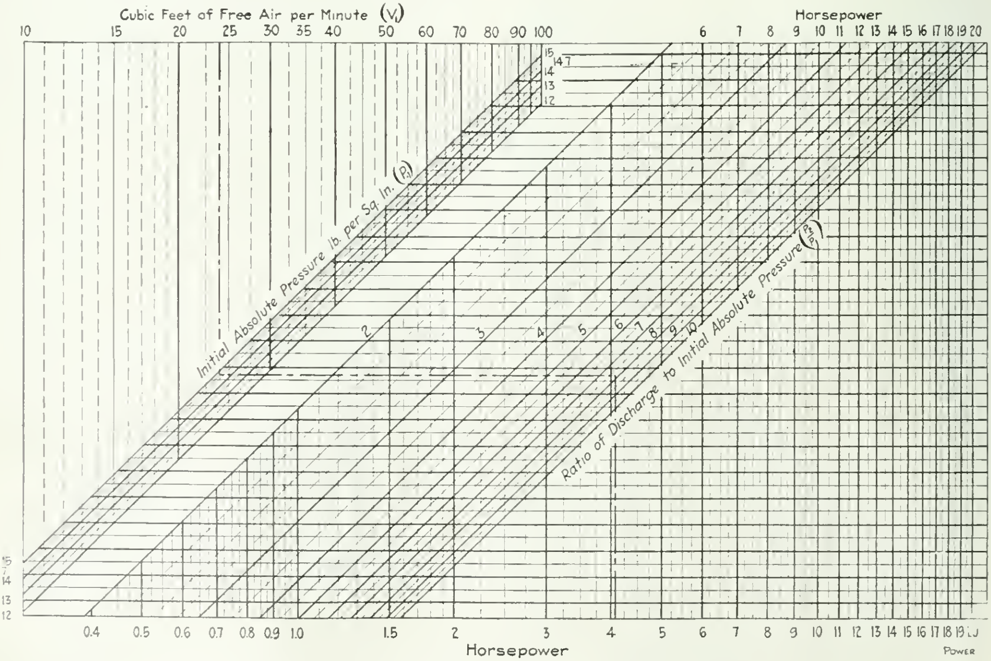


Fig. 1. Chart for Determining Horsepower Required to Compress Given Volume of Air from One Pressure to Higher Pressure

n = Factor varying in air compressors from 1.25 to 1.35, depending on the efficiency of cooling by the jacket. A common value of this factor is 1.30.

This formula is long and tedious to apply, especially if one is not familiar with the use of logarithms and calculating devices. It is for the purpose of solving this formula graphically that Fig. 1 was designed. The heavy broken line indicates how the chart is to be used but possibly a brief explanation will make it clearer. The data for the problem solved is as follows:

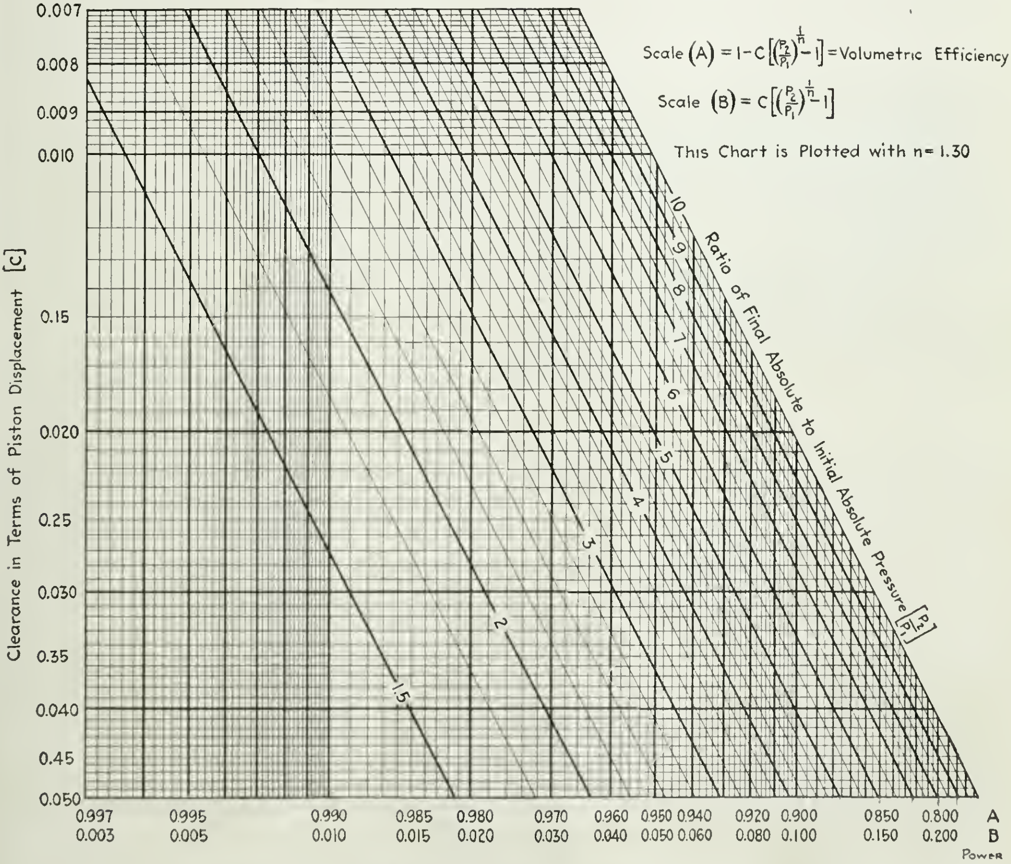


FIG. 2. CHART FOR DETERMINING VOLUMETRIC EFFICIENCY OF AIR COMPRESSOR

Volume to be compressed per minute (V_1) = 24 cu.ft.; initial absolute pressure (P_1) = 14.7 lb.; discharge absolute pressure (P_2) = 114.7 lb.

Solution: Starting with the volume of 24 cu.ft. at the top of the chart drop vertically down to the diagonal line representing the suction pressure of 14.7 lb. From there follow to the right to a point between the two diagonal lines labeled 7 and 8 respectively, or to be exact to a point representing 7.8, the value of the ratio

$$P_2 \div P_1 = 114.7 \div 14.7 = 7.8$$

Then drop vertically down to the answer of 4.1 hp. at the bottom of the chart. If a mechanical efficiency of 85 per cent. is assumed the indicated horsepower of the driving engine is

$$4.1 \div 0.85 = 4.82$$

It will be evident that a problem with the same data as above, except that V_1 be 240 cu.ft. per min., would be solved by using the same line and that the answer would be 41 hp., the difference in the solution being in the placing of the decimal point. The range in volume of air on the chart being from 10 to 100 cu.ft. per min. makes the range unlimited by merely shifting the decimal point on the volume scale and making the corresponding change on the horsepower scale.

The value of the factor n for which the chart was plotted is 1.30. This figure was chosen because it is the value most commonly used. In Table 1 are given factors by which to multiply the results when n has a value other than 1.30. To illustrate its use assume that n in the above problem has a value of 1.40, the value for adiabatic

TABLE 1. FACTORS BY WHICH TO MULTIPLY RESULTS WHEN n HAS VALUE OTHER THAN 1.3

	Values of $P_2 \div P_1$								
n	2	3	4	5	6	7	8	9	10
1.20	0.976	0.962	0.953	0.946	0.941	0.936	0.932	0.927	0.927
1.25	0.988	0.982	0.977	0.974	0.971	0.969	0.966	0.963	0.962
1.35	1.008	1.017	1.020	1.024	1.028	1.031	1.033	1.036	1.038
1.40	1.016	1.029	1.039	1.048	1.055	1.059	1.063	1.067	1.071

compression of air. The proper factor by which to multiply will be found in the bottom line of the table 0.8 of the way between 1.059 and 1.063, which is equal to 1.062. Therefore, multiplying the chart answer of 4.1 hp. by 1.062 gives 4.35 hp., the desired result.

The use of the chart is not necessarily limited to air problems, since by using the proper value of n it is applicable to any gas. In general the value of n is slightly less than the ratio of the specific heat at constant pressure to that at constant volume of the gas in question.

While the chart is primarily designed to solve problems for single-stage compression, it may be used also to determine the necessary power for two-stage compression. It can be shown that for the most economical results in two-stage compression the intermediate pressure should be equal to the square root of the product of the suction and discharge pressures; i.e., equal to $\sqrt{P_1 P_2}$. It may also be shown that for this intermediate pressure the work done in each of the two cylinders is exactly the same. Therefore, having determined the intermediate pressure, which will be called P', the horsepower absorbed in each of the two cylinders is:

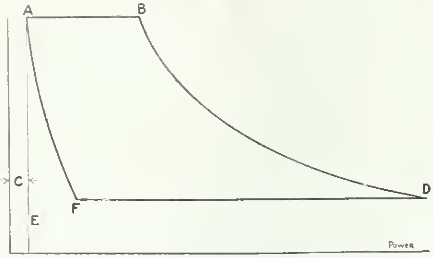


FIG. 3. INDICATOR DIAGRAM FROM AIR COMPRESSOR

$$hp. = \frac{144\ P_1\ V_1}{33{,}000} \times \frac{n}{n-1}\left[\left(\frac{P'}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

the same formula which the chart was designed to solve. Therefore, having obtained the result of this solution from the chart the total horsepower absorbed in both cylinders is obtained by multiplying by two. To illustrate, assume the same data as for the above problem except that the compression is to be two stage.

Solution: The intermediate pressure is

$$P' = \sqrt{P_2 P_1} = \sqrt{114.7 \times 14.7} = 41.06\ lb.$$

Then the ratio of compression $P' \div P_1$ in the low-pressure cylinder is

$$41.06 \div 14.7 = 2.79$$

For 24 cu.ft. of air per min. and this ratio of compression, the chart gives a value of 1.80 hp. Therefore, the total horsepower absorbed in both cylinders is

$$2 \times 1.80 = 3.60$$

Assuming a mechanical efficiency of 85 per cent., the indicated horsepower of the driving engine is

$$3.60 \div 0.85 = 4.23$$

Fig. 2 becomes useful when it is desired to determine the necessary piston displacement of a compressor to deliver a definite volume of free air under given conditions of suction and discharge pressure. Also in calculating the probable amount of air that a compressor of given dimensions will deliver under given conditions of suction and discharge pressure and speed.

Referring to Fig. 3, representing the indicator diagram of an air compressor, it is evident that when the piston reaches the end of the discharge, or compression stroke, corresponding to the point A, that the clearance volume C will be full of air at discharge pressure. This air will expand as the piston starts back on the suction stroke and no air will be drawn into the cylinder until the pressure therein has fallen to the suction pressure. Hence the volume of air drawn in each stroke will be somewhat less than the piston displacement, the amount being dependent upon the clearance volume and the ratio of the discharge to the suction pressure. The ratio of the air drawn into the cylinder per stroke to the volume of the piston displacement is called the volumetric efficiency of the compressor. In Fig. 3 this ratio is approximately $DF \div DE$. Mathematically expressed the volumetric efficiency is:

$$1 - C\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

in which C is the clearance volume in terms of the piston displacement and the rest of the notation has the same meaning as in the previous formula.

Fig. 2 is for the purpose of solving this formula. The method of using it is self-evident, but to make it perfectly clear the following example will be solved.

Given: Clearance volume $C = 0.02$ of piston displacement: $P_1 = 14.7$ lb. abs.; $P_2 = 75$ lb. abs.

Required: The volumetric efficiency.

Solution: Starting on the left-hand side of the diagram at 0.020 go in a horizontal direction to a point between the two diagonal lines labeled 5 and 6 respectively, or to be exact to a point representing the value of

$$P_2 \div P_1 = 75 \div 14.7 = 5.1$$

From there drop vertically down to the answer on scale A, which for this case is 0.950.

To make the diagram applicable to problems in which n has a value other than 1.30 the scale B has been placed on the diagram. This is equal to 1 — scale A, or to

$$C\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

To solve problems similar to the above when n has a value other than 1.30 proceed in exactly the same manner except that the result is read on scale B. Then multiply this by the proper factor from Table 2 and subtract the result from 1, giving the desired volumetric efficiency.

TABLE 2. FACTORS BY WHICH TO MULTIPLY SCALE B IN FIG. 2 WHEN n HAS A VALUE OTHER THAN 1.30

	Values of the Ratio $P_2 \div P_1$									
n	1.5	2	3	4	5	6	7	8	9	10
1.20	1.097	1.112	1.132	1.150	1.162	1.169	1.178	1.187	1.192	1.196
1.25	1.041	1.064	1.070	1.077	1.080	1.082	1.088	1.091	1.093	1.095
1.35	0.959	0.950	0.941	0.936	0.932	0.929	0.927	0.926	0.924	0.922
1.40	0.918	0.907	0.892	0.886	0.880	0.872	0.866	0.864	0.860	0.857

As a last example involving the use of both charts, take the following problem: A single-stage compressor is desired which will compress 2000 cu.ft. of free air per min. from a pressure of 14.7 lb. abs. to a pressure of 70 lb. abs. What should be the piston displacement per minute, and what should be the indicated horsepower of the engine, assuming a mechanical efficiency of 85 per cent.

Solution: From Fig. 1 the power absorbed in the cylinder by the air is 238 hp. Then

$$238 \div 0.85 = 280$$

as the indicated horsepower of the driving engine.

From Fig. 2 the volumetric efficiency is found to be (assuming a clearance of 2 per cent.) 0.954. Dividing 2000 by 0.954 gives 2096 cu.ft.

To allow for leakage past the piston back through the discharge valves, for effect of rise in temperature during the suction stroke, etc., this quantity should be increased by from 3 to 8 per cent. Therefore, assuming the loss due to these causes to be 5 per cent., the required piston displacement becomes

$$1.05 \times 2096 = 2200.8 \text{ cu.ft. per min.}$$

Largest Diesel Engine Built in America

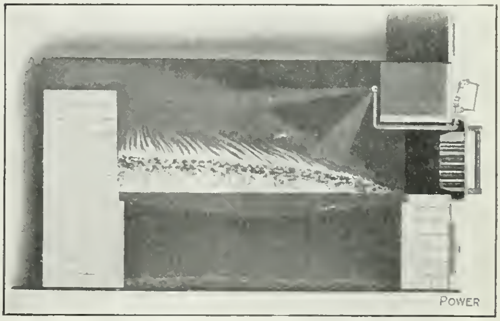
The accompanying photograph shows the largest Diesel engine constructed to date in this country. It was built by the Lyons Atlas Co., of Indianapolis, for the Hawaiian Commercial & Sugar Co., to supersede one of their steam plants for irrigation purposes. It has four cylinders, 21x30 in., is rated normally at 600 hp., or 690 hp. maximum, and will drive a two-stage turbine pump of 15,000,000 gal. capacity at 200-ft. head.

The conditions covering the acceptance of the engine were severe. The purchaser insisted that the engine should operate continuously 710 hr. out of each 720 hr. per month at rated load, using the ordinary 14° to 18° asphaltum base California fuel oil, similar to that used in the purchaser's steam plant, and which is the only grade available on the Islands.

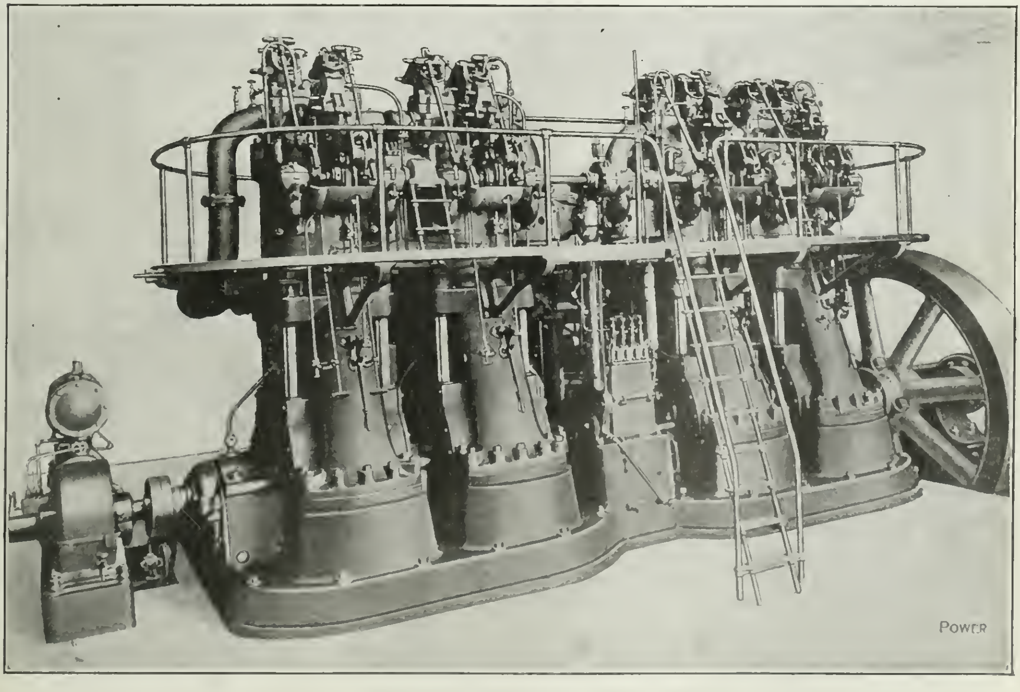
The test was conducted by the chief engineer of the Hawaiian Commercial & Sugar Co., and the engine was given a preliminary, continuous run of 48 hours with Eastern paraffin-base fuel, after which all parts connected with the combustion chambers were inspected in order to determine a basis for comparison between the effect of the two fuels. It was then subjected to a 144-hr. continuous run at full load with fuel shipped by the purchaser from California to the manufacturer's works. At the completion of this run the combustion chambers were again examined, and as no evidence of deposits on the heads, valves or pistons were found, the engine was accepted and is now *en route* to the Islands.

Morse Smoke Consumer

The most active cause of smoke when using soft coal in boiler furnaces is the rapid distillation of volatile from the new coal when first thrown on the incandescent or nearly incandescent fuel bed. During this time of rapid



THE MORSE SMOKE CONSUMER



600-HORSEPOWER, LYONS-ATLAS DIESEL ENGINE distillation the supply of air or oxygen should be greater than normal, and, if hot, will produce better results, because there is quite a drop in furnace temperature when a hot bed is covered with new and cold fuel and cold air from the room rushes in through the fire door.

The smoke consumer marketed by the R. F. Morse Co., Providence, R. I., has been designed to automatically furnish the increased oxygen at a temperature much higher than that of the room air, and also to retard the flow of gases from the fuel bed sufficiently to allow them to burn before reaching the flue and stack.

These effects are produced by two steam jets, both being projected from a nozzle at the front of the furnace, one so that it is over the fuel bed, the other being projected at a sharp angle, so that it forms a curtain on the inside of the furnace at the fire-door opening. The latter curtain tends to reduce the amount of cold air admitted into the furnace through the fire door, and also furnishes air or oxygen at a temperature above that of the room. Besides furnishing heated air or oxygen, the top curtain tends to retard the flow of gases from the furnace. When the fire door is open, preparatory to charging the furnace, both jets are automatically turned on, and, when closed, the jets are slowly shut off. The back of the fire door is provided with a heater for warming the air admitted to the furnace at this point. The device may be attached to any horizontal boiler furnace without dismantling the furnace or shutting down the boiler.

⁂ ⁂

Applications and Types of Boosters

By John A. Randolph

SYNOPSIS—The classification and uses of automatic and non-automatic boosters, and descriptions of the shunt, series, compound and differential types.

⁂

The function of the booster, as implied in its name, is to raise or boost the voltage of electrical circuits. The machine is simply a direct-current generator with the armature and field windings so arranged as to adapt it to the particular service for which it is used. On many systems conditions exist such that it is necessary at times to raise the voltage on certain circuits, either to compensate for line drop or to overcome an opposing pressure, as in charging or discharging a storage battery. The booster is used for both of these purposes, but its most extensive application is in connection with storage-battery installations, wherein it renders possible a broad range of flexibility.

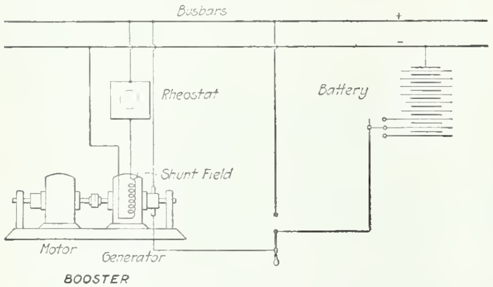


Fig. 1. Shunt Booster

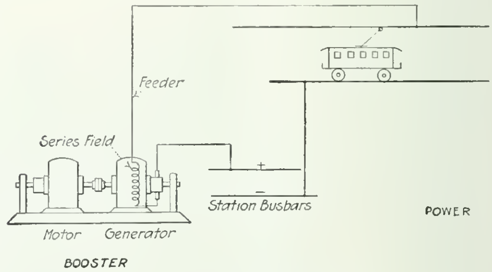


Fig. 2. Series Booster

The various types of boosters can, in general, be classified under two headings, namely, the automatic or reversible class and the nonautomatic or irreversible class. The automatic machines are those which charge or reverse their action, without external assistance, from adding their voltage to the station pressure for battery charging, to opposing the station voltage and assisting the battery to discharge. In the nonautomatic group belong those which cannot be reversed at all and those which require the throwing over of a reversing switch before they will change their polarity. In the latter class can be grouped the shunt, series and compound machines, while the automatic class includes the differential and exciter-controlled types.

Shunt Type

This form has one field coil connected either across the station busbars, the battery or the booster itself. As is usual with shunt-wound machines, a rheostat is placed in the field circuit for regulating the excitation. Fig. 1 shows a diagram of connections commonly used for machines of this type. In charging, the single-pole, double-throw switch is thrown downward, and the charging current may be regulated to any desired value by the booster field rheostat. By placing a reversing switch in the booster field circuit, the polarity can be reversed, enabling the machine to assist the battery on discharge when its voltage has fallen to a value nearly equal to or below that of the station busbars. By the use of end cells the battery can be discharged without assistance from the booster. No end cells are necessary, however if the booster is used during discharge. Where the machine is used for both charging and discharging it must be run continuously during both periods. If the booster is to be used on discharge, it must be of a larger construction than otherwise, because of the much heavier current passing on discharge than on charge.

The shunt booster is hand-operated and nonautomatic, hence it must be constantly watched in order to provide the adjustments necessary to compensate for the gradually rising or falling battery voltage.

SERIES TYPE

This machine, like the shunt type, has but one field coil, which is in series with the armature, as shown in Fig. 2. In the case illustrated, the machine is used in connection with a long railway feeder. At distant points on such feeders the voltage, unless raised by some means at the station end, is lower than that of the busbars, especially during heavy loads, on account of the loss of pressure due to line drop. This difficulty could be obviated by the installation of a larger copper cross-section, but in many cases it is more economical to use a booster. Where a series machine is used, the full current of the feeder passes through the field coil of the booster, and as the load on the feeder, and the consequent line drop, increases, the voltage of the booster will rise proportionately, thus compensating for the line drop and maintaining a constant pressure at the distant points on the feeder.

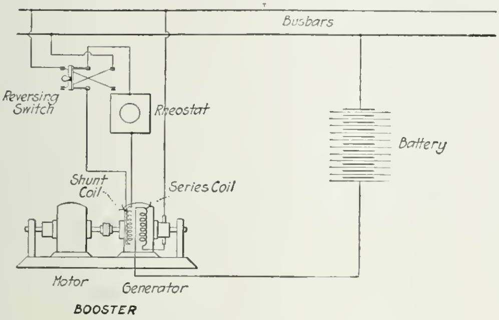


FIG. 3. COMPOUND BOOSTER

COMPOUND TYPE

The connections for this type are shown in Fig. 3. The field winding is made up of two sets of coils, one in series with the armature and load and the other shunted across the station busbars. By virtue of its two sets of windings, this machine can be made to act automatically under certain conditions. It is generally classed as a nonautomatic machine, however, since there are times when it is necessary to throw over the shunt field reversing switch to secure the proper polarity. When the machine is acting automatically, the battery can float on the line. Under such a condition, the shunt coil is made to produce a pressure in the booster, tending to assist the battery to discharge. The series coil is wound in such a direction that it assists the action of the shunt coil on discharge and opposes it on charge.

Inasmuch as the tendency of both windings is to cause the booster to assist the battery on discharge, the battery will at once take part of the station load whenever the demand becomes so great as to reduce the busbar voltage below the value of the battery pressure plus that of the booster. Now the voltage at the booster terminals, as induced by the series coil, will vary with the strength of the current flowing through the latter. Consequently, as the load on the battery increases, the booster voltage will rise accordingly, helping the battery to meet its demand and thereby maintain the voltage on the busbars. As the station load falls off, the busbar voltage will gradually rise until it becomes equal to the combined pressures of the battery and the booster, thus counterbalancing the latter. During this state of equilibrium no current will flow either way through the battery. However, as the station load is still further reduced, the busbar voltage will rise higher, with the result that the equilibrium between the battery and the busbars is overcome and a charging current begins to flow into the battery. The series winding will now oppose the shunt and tend to remove the opposition of the booster pressure to the charging current.

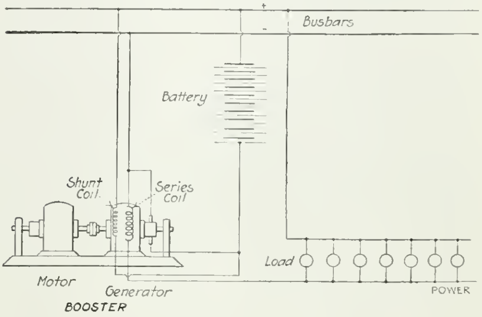


FIG. 4. DIFFERENTIAL BOOSTER WITH ONE SERIES AND ONE SHUNT COIL

The charging and discharging are for the most part automatic. However, owing to irregularities in the loads, it may be necessary at times to vary the excitation current in the shunt coil, or even to reverse it. A reversal is necessary when it is desired to cause the shunt coil to assist the busbar pressure in charging the battery instead of opposing it as at normal. A reversing switch is provided in the shunt circuit for this purpose.

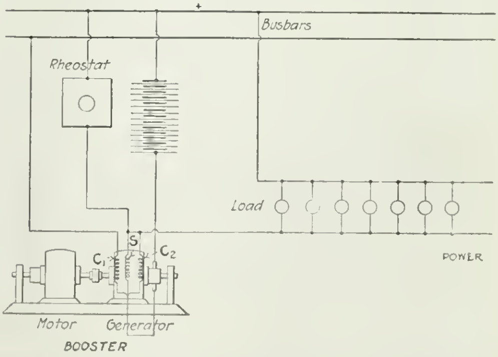


FIG. 5. DIFFERENTIAL BOOSTER WITH TWO SERIES COILS

DIFFERENTIAL TYPE

This type is of the automatic class and exists in several forms, one of which is shown in Fig. 4. This machine has a winding in series with one side of the station load. In addition to the series winding is a shunt coil connected across the battery. The latter winding is so wound as to produce a pressure in the same direction as that of the busbars, whereas the series winding tends to oppose the latter. On heavy loads, therefore, the series winding overpowers the shunt and causes the booster voltage to rise to a value which enables the battery to discharge and take part of the load. On light loads, the shunt winding overpowers the series, with the result that a charging current begins to flow into the battery.

The differential booster as most generally used is shown diagrammatically in Fig. 5, where S is a shunt coil which tends to cause the booster to act with the main pressure and send a charging current into the battery; C_1 and C_2 are series coils acting in opposition to the shunt coil. By the arrangement of the series coils, it will be seen that C_1 at all times carries the total load current flowing from the main supply source only, while the coil C_2 carries the total external load, including the part supplied by the battery. During periods of heavy load, therefore, the field produced by the coils C_1 and C_2, which coils act in the same direction, will overpower that of the shunt winding, thereby causing the booster to oppose the station voltage and assist the battery to discharge. As the load falls off, coils C_1 and C_2 become less active until a point is reached where the battery neither charges nor discharges. Below this point, the shunt coil overcomes the action of the series coils, with the result that a charging current begins to flow into the battery. The action is similar to that shown in Fig. 4, except that in the machine of Fig. 5 a more stable equilibrium is given to systems with rapidly fluctuating and widely variable loads. This is because coil C_1, producing a voltage opposite to that of the main busbars, tends to prevent a heavy current from flowing into the battery in case the voltage of the latter has been much reduced by a long-continued discharge. On the other hand, the coil C_1 renders a greater impetus to a discharge of the battery under a sudden heavy external load, thus relieving the station busbars from the necessity of taking all of the load and losing part of their pressure in consequence. By performing these functions, the coil C_1 tends to keep a more nearly constant load on the station busbars than would otherwise be maintained.

⁂ ⁂

Operating Costs in a Power Plant

By W. G. Lighty

SYNOPSIS—Data on an office-building plant covering the cost of current, heating and elevator service. Results of a special test to determine the coal taken by the elevators.

⁂

A certain office building in Chicago, which is 72x150 ft. in plan by 16 stories high, was equipped with four return-tubular, hand-fired boilers 60 in. by 17 ft. Each was provided with a shaking grate having 25 sq.ft. of surface. Illinois Carterville washed nut coal was burned. The draft at the stack was 0.6 in., and 0.3 in. over the fire. Due to age, the general condition of the boilers and settings was poor and each year the working pressure, which was 90 lb. gage, was in danger of being reduced by the city inspectors.

A generating capacity of 300 kw. was installed. The load averaged about 30,000 kw.-hr. per month, or 360,000 kw.-hr. per year. This was divided about half and half between the building and the tenants, the current being sold to the latter at 7c. per kw.-hr. The building was heated by 30,000 sq.ft. of radiation.

Four hydraulic passenger elevators, each having a capacity of 2500 lb., served the building, two running to the sixteenth and two to the thirteenth floor. The elevator pumps consisted of a 14, 22 and 11 by 18-in. duplex and two smaller pumps having a combined capacity about equal to the large one.

On an average, 262 tons of coal were burned per month, or 3144 tons per year. At $2.65 to $2.70 per ton, the coal bill amounted to about $9000 per year. For labor, the annual expenditure was $6950, made up of wages to a chief engineer, three assistant engineers, three firemen and one oiler. The total operating expenses for an average year, as taken from the log, is given in Table 1.

TABLE 1 OPERATING COST PER YEAR

Coal	$9,000
Wages	6,950
Supplies	600
Repairs	1,000
Total	$17,550

Allowing 100 lb. of coal per square foot of radiating surface per season, the heating system would require, if run independently,

$$\frac{30,000 \times 100}{2000} = 1500 \ \textit{tons}$$

This is practically half the coal, and from a fuel basis alone, would mean 13c. per sq.ft. of radiation. There are other charges, such as labor, upkeep, etc., of which the heating system should bear its share. Taking 25c. per sq.ft. as a fair rate (it would be more than this if obtained from a central heating plant), the charge against the heating system would be $7500.

It was proved by test that the elevators were responsible for 35 per cent. of the coal consumption, and taking this percentage of the total expense, the annual charge against the elevators is $6142.50. Deducting this amount and the charge for heating from the total leaves

$$\$17,550 - (\$7500 + \$6142.50) = \$3907.50$$

as the charge against the generation of current. Per kilowatt-hour, this reduces to

$$3907.50 \div 360,000 = 1.085\text{c.}$$

The plant should then be credited as indicated in Table 2.

TABLE 2 CREDITS TO PLANT

180,000 kw.-hr. at 1.085c.	$1953.00
180,000 kw.-hr. at 7c.	12,600.00
30,000 sq.ft. radiation at 25c.	7,500.00
Elevators, 35% annual expense	6,142.50
Total	$28,195.50

This gives a profit to the plant of

$$\$28,195.50 - \$17,550 = \$10,645.50$$

Taking it another way, the cost of current to the tenants might be deducted from the total expense, and the charge to the different departments lessened in their proper proportion.

Due to the condition of the boilers, it was a question whether to reduce the pressure and use them for heating, change the elevators from hydraulic to electric and use purchased current, or to install new boilers. To determine this point, a day was set aside to test the elevator plant and learn as closely as possible the amount of coal required, the volume of water pumped, the passengers carried, the horsepower developed and the cost per car-mile for coal. The test was started at 7 a.m., and continued until midnight. The results are plotted in the accompanying chart.

One boiler was designated to supply the steam, and the large duplex pump was used. The usual operating pressures and schedule of running were followed. The boiler pressure was 90 lb. gage, and the pump worked with an initial steam pressure of 73 to 75 lb. against a back pressure of 2½ lb. The water pressure was 150 lb. No. 3 elevator was operated from 7 a.m. to midnight, No. 2 from 7:30 a.m. to 6:30 p.m. and from 7:50 p.m. to 9.28 p.m., No. 1 from 8:38 a.m. to 6 p.m., and No. 4 from 9:10 a.m. to 5 p.m. The number of passengers up and down was recorded every 15 min. The gallons of water pumped were obtained by recording the number of strokes of the pump, a special counter being fitted up for the purpose, and measuring the length of stroke to obtain the average. The coal and water fed to the boiler were weighed. The evaporation of water per pound of coal as fired was 5.17 lb., or about 6 lb. from and at 212 deg. Ordinarily, better results were obtained, but during the test a 100-hp. boiler was carrying on an average only 65 hp., whereas it had been the practice to operate the boilers at 30 per cent. overload. In Table 3 is given for each hour the car-mileage, the cost of coal and the cost per car-mile. In the chart number of passengers should be read at the end of each 15-min. period, but the other items, such as coal and water, were plotted in hourly quantities, so that the reading from the curves should be taken at the end of each hour.

TABLE 3. COST OF COAL PER CAR MILE

			a.m.								p.m.						
Time......	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Car mileage. ..	1.22	3.52	5	4 86	4 79	4 56	5.33	4.86	4 45	5.04	4.25	2 75	1.99	1 86	1.40	1 08	0.53
Coal per hr, lb...	315	360	390	330	390	320	390	395	400	310	390	305	300	295	125	125	50
Cost of coal, c....	42.05	48.06	52.06	44 05	52 06	42 72	52 06	52 73	53 40	41 38	52 06	40 72	40 05	39 38	16 69	16.69	6 67
Cost per car mile, c	34.47	13.65	10.41	9.06	10.87	9.37	9 76	10.85	12	8 21	12.25	14 81	20 12	21.17	11.92	15.45	12.59

As given in Table 3, the car-miles for the 17 hr. per day which the cars were run, totals 57.41; on some days the mileage was greater. During the year in which the test was made the total mileage was 25,632. The cost for coal averaged 13.94c. per car-mile. In the morning, when the load was light and the trips less frequent, it ran as high as 31.47c. and during the peak load at 5 p.m. it dropped to 8.21c. The average cost for the nine busiest hours, 9 a.m. to 6 p.m., was 10.31c. per car-mile.

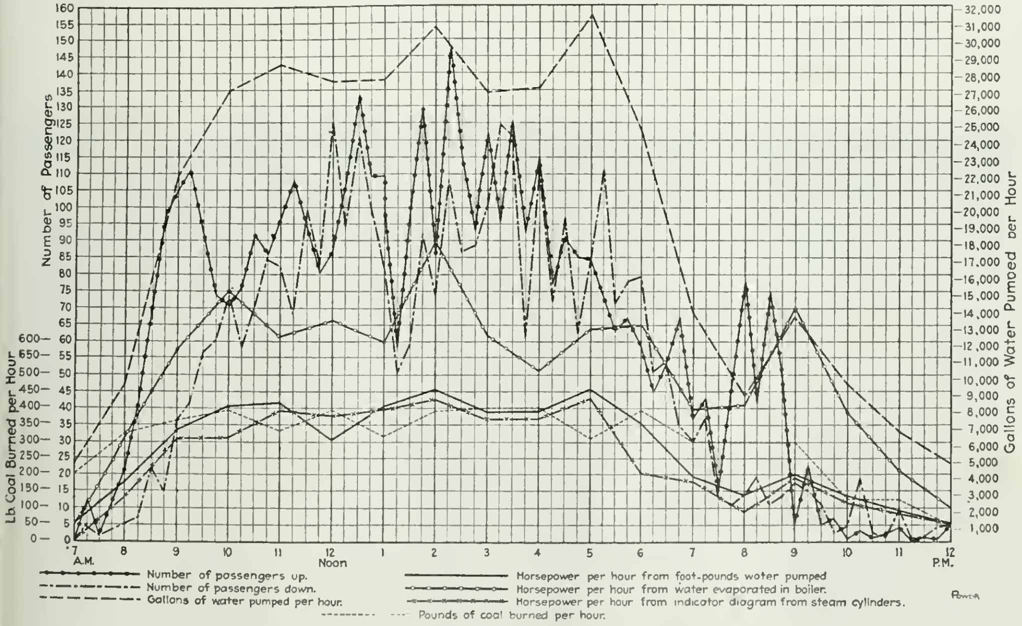


CHART SHOWING OPERATING TEST OF ELEVATOR

As stated, the elevators are responsible for 35 per cent. of the coal. The annual cost was $9000 and the above percentage of this is $3150. Dividing by the mileage per year gives 12.3c. per car-mile. If 35 per cent. of the entire operating cost of the plant were charged to the elevators, the rate would be nearly 24c. per car-mile. This includes the upkeep of the cars, except cabling, but not the wages of the elevator operators.

It may be of interest that as a result of the test two new 130-hp. boilers were installed to take the place of the old boiler plant. With the same electric load and an increase in the elevator load, a saving of 23 per cent. in the coal bill was effected the first year.

An Old-Time Engine

By R. H. Porter

The oldest steam engine in use in central Iowa, and perhaps in the state, is owned and used by the Madrid Milling Co., Madrid, Iowa. It was hauled by wagon from Keokuk to a place a few miles north of Madrid in 1855, and ran a sawmill. In 1868, the engine was brought to Madrid and operated in a grist and sawmill. When it came into the hands of the present owners it ran a flouring mill.

The old engine has been in constant operation since its arrival in the state and has outlived four boilers. To see it running today, one would hardly realize it has almost 60 years of service to its credit. There is no nameplate or mark by which to identify the manufacturer. As to its steam economy, there is nothing to say.

The cast-iron bed is made in four sections, bolted together at the corners, and is about 12 ft. long and 18 in. wide. The 8x22-in. cylinder is not lagged to retain its heat. The valve chest containing the simple D-valve is bolted to the top of the cylinder. The 2-in. steel piston rod is keyed to a cast-iron crosshead, the shoes of which are of hickory and have to be replaced about every two or three months. Originally, the valve rod was of one piece, but owing to the cutting of the packing a knuckle joint was used.

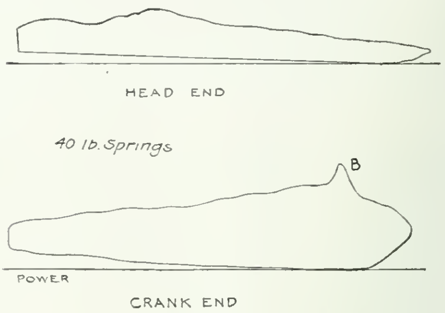


Fig. 2. Diagrams Taken from Engine

One of the interesting features of this old engine is the attachment of the eccentric rod to the rocker-arm,

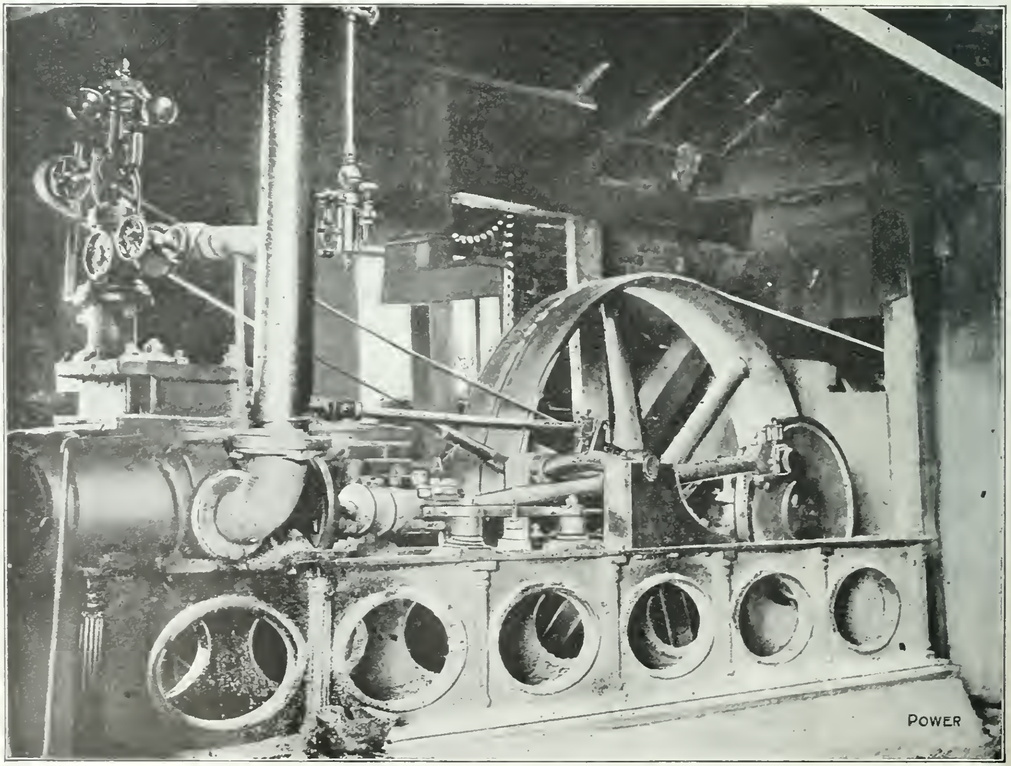


Fig. 1. Engine with 59 Years of Service to Its Credit

the connection being the same as that on some of the early Corliss engines to connect the reach rod to the wrist plate, having only a slot in the arm. On the rocker-arm is a lever *A*, Fig. 1, about 2 in. in diameter and 18 in. long, which was used to work the valve and free the cylinder of water before the drain connections were put on.

The 5-in. crankshaft is of cast iron and about 5 ft. long. No evidence of being trued up in any way is shown on the cast-iron flywheel.

Two diagrams, Fig. 2, were taken from the head and crank ends, respectively, as the engine was running in the summer of 1912. The indicator was attached to the cylinder through the drain-cock openings and the peak at *B* was due to a slug of water coming into the indicator: the diagrams figure 13 i.hp. at 105 r.p.m.

The engine is throttle governed, steam being supplied by a 3-in. main, and the exhaust is 4 in. in diameter. The governor, lubricator and grease cups are modern additions to the engine.

* *

Testing and Adjusting Steam Gages

By F. W. Bentley, Jr.

SYNOPSIS—A practical article dealing with the testing and adjustment of the Bourdon-type pressure gage. Tells how to construct a testing outfit from fittings found in the stock room of almost any plant. Test for correct readings at all pressures: what to do when a gage registers uniformly high or low. Correcting a gage in which the error increases as the pressure becomes greater. Taking up lost motion. Refinishing the face of the dial.

*

Testing and adjusting the dial pressure gage for accuracy is a frequent necessity. A suitable testing apparatus is another necessity which many plants do not possess. In Fig. 1 a home-made device is shown which will answer all requirements; it is not so elaborate as many of the higher-priced arrangements, yet any ordinary gage can be carefully set and adjusted with it. Ordinarily, the only part which need be purchased is the adjusting or monitor gage *A*. The barrel or pressure cylinder of the device is simply a piece of 2- or 3-in. pipe bored out with a cut sufficiently fine and clean to enable the piston leather to hold the oil as it is compressed by the screw to register the pressures on the gages. The rest of the apparatus is, for the most part, simply ¼-in. pipe fittings, all of which are a part of any plant's repair stock.

As the majority of gages now used are of the Bourdon-tube type, the following description applies to such gages. The provisions for adjustment on any type of gage, however, are much the same, all principles of operation being practically alike:

Assume that we have a gage for test and comparison with the monitor gage of the testing device. If the pressure registers the same at all graduations and the hand of the gage under test is sensitive to all slight movements of the ram spindle, we need go no further. A common defect is to have the gage under test continually show an excess in registered pressure over that of the monitor. If this excess is constant at all pressures, a resetting of the hand is all that is needed to correct the gage for use again.

Take a case where the gage is so defective that it may require not a little experimenting and adjustment to make it register perfectly at all points on the dial. Suppose the gage shows this defect, that at 10, 20 and even 30 lb. resistance against the plunger, it registers perfectly with the graduations on the monitor gage, but at 40 lb. reads a trifle in excess of what it should, say, 2 or 3 lb. At 50 the hand may be in advance to an error of 5 lb. The writer has adjusted gages which at 150 lb. showed as much as 20 lb. in excess of the pressure shown at that point by the monitor. This action plainly shows that the hand is traveling too far for the corresponding amount of expansion of the pressure or expansion tubes of the gage as the plunger increases the amount of resistance within them.

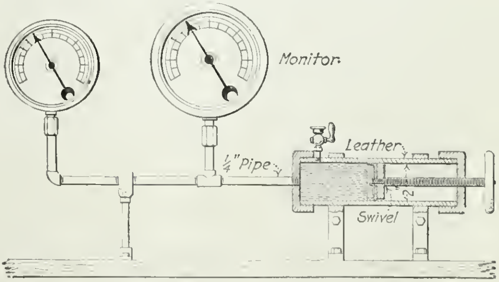


FIG. 1

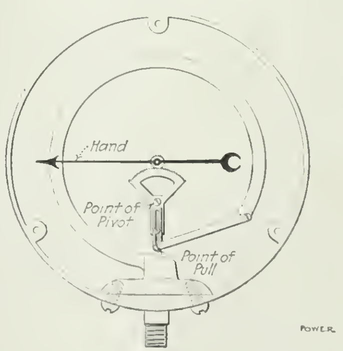


FIG. 2

Showing the Test Pump and Gage Mechanism

Fig. 2 is a sketch of the general interior of the average gage, but the provision for adjusting and correcting the above defect can be more clearly understood by reference to Fig. 3. The pull rod *A* is attached to the lower end of the gear segment through the small slide *B*. The screw *C* allows the slide to work up and down on the body of the segment. This brings the point of pull further away from or closer to the point of pivot.

The object of this provision may be understood more clearly perhaps by reference to Fig. 4. We have a strip of wood through which we place a pin as an axis at its exact center. Now, if we move the end *A* through a space of 1 in., we get a movement of 1 in. at the other. We place the pin closer to the end *A* and again give it a movement of 1 in. This time the free end of the stick moves much further. This illustrates the same principle of the purpose of the slide on the segment of the gage. If we loosen the screw *C*, Fig. 3, and move the slide up, we get a greater arc traveled through by the toothed portion of the segment. Moving the slide down brings the point of pull further away from the point of pivot and results in a lesser travel of the segment and consequently a reduced amount of register by the small pinion controlling the gage hand.

As we cannot adjust the hand travel with the dial of the gage in place, we must resort to other means for keeping the register marks continually in view during the process of correction. Before removing the dial, small nicks must be made in the thin edge of the gage casing, directly above or opposite the graduations on the dial when the dial is in place. The amount of pressure these little nicks indicate is marked with chalk near them, as shown in Fig. 5. When the dial is removed and the hand is temporarily applied for adjustment, we have something to guide us as the slide is moved up and down to bring the travel of the hand to its correct travel with the corresponding tube expansion to register correctly at all graduations. After this has been accomplished the hand is removed, the dial applied and the hand reset.

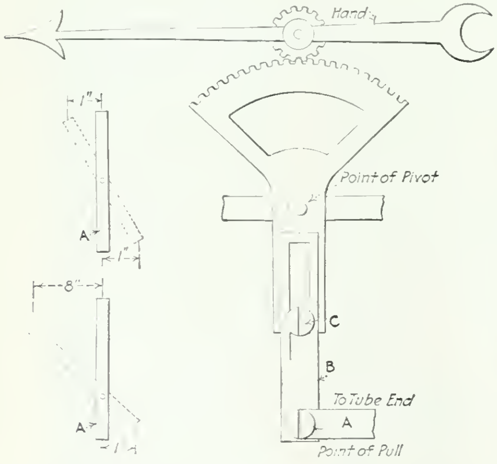


FIG 4 FIG. 3

Gage Mechanism, Showing Adjusting Screw *C* and Deflection of Gear Segment

Lost motion caused by the wear of the holes through the small connecting levers is another trouble which can be easily remedied. These holes can be closed a trifle with the peen of a small light hammer. A fine rat-tail file will enlarge them well enough to again take the body of the tap screw with all lost motion eliminated. Lost motion has no evil effects on the gage to speak of if the adjustment is correct, yet at the same time it is an easy matter to remove it; this operation lessens quivering of the hand should the gage be subject to much vibration.

The gage dial is often subject to the effects of heat and moisture, which in time corrode it, making the face figures sometimes almost indistinguishable. The paint or enamel down in the figure recesses will crack and fall out from the effects of heat and moisture. The gage-dial face is best cleaned with finely powdered glass and oil.

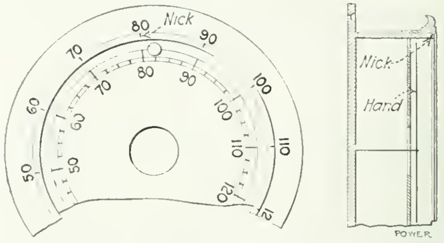


Fig. 5. Showing Where the Case Is Marked during Test

In retouching the figures, the following is an excellent method: the paint should be daubed thoroughly into the sunken portions of the dial, and the surplus wiped off with stiff porous paper. The paper, being flat and stiff, does not disturb the paint in the figure recesses, but in cleaning the remainder of the dial it leaves the graduations clear and distinct.

⁂

Portable Greaser

The appliance illustrated herewith was designed by John C. White, who is in charge of the Capitol Power Plant at Madison, Wis., for the occasional application of grease to small bearings which it is not desirable or convenient to equip with compression cups. The grease is put under pressure by screwing the plunger down upon it. The grease holes of the bearings are cupped as shown to receive the conical nozzle. With the nozzle in place, as in Fig. 2, the hand is pressed upon the head *H*, forcing the valve *V* open against the action of the spring, and allowing grease to escape under pressure into the bearing. In this way grease may be used with all the handiness and with much more cleanliness and positiveness of application than oil with the ordinary can. It is not upon the market, nor even patented, and anybody is free to make and use it.

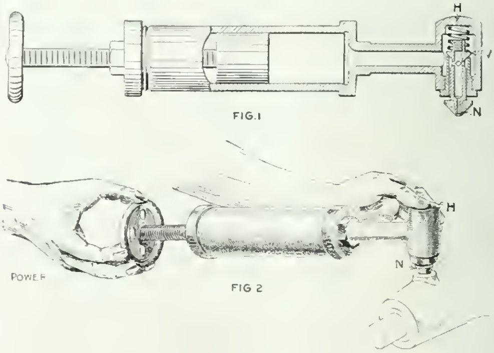


FIG. 1

FIG 2

Portable Greaser

Editorials

Adamson Water-Power Bill

At last definite action upon the water-power situation seems assured. Several bills pertaining to this subject have been introduced in the present Congress, but their shortcomings have been such as to bring about their defeat. The Adamson bill, however, which passed the House of Representatives on Aug. 4, as an amendment to the "General Dams Act," is now before the Senate, and as it is understood to have the backing of the administration, its passage is looked for. In its present form, it appears to reasonably safeguard the interests of the public, at the same time maintaining a fair attitude toward the power companies. Presumably the Senate will offer several amendments, but in doing so it is hoped that some of the loose provisions will be strengthened rather than any of the meritorious features eliminated. The principal points of the bill may be summarized briefly as follows:

There are the usual provisions for safeguarding navigation, and after a grant has been made for power development, complete plans of the project must be submitted within two years. The project must then be completed within three years after the plans have been approved unless, for some very good reason, an extension of time is granted by the Secretary of War. Also, it is the duty of the latter to see that development proceeds as fast as the demands of the available market warrant. This clause, if carried out, would effectively prevent the holding of undeveloped water powers for monopolistic purposes.

Grants under this act would be for a period of 50 years, at the expiration of which, or any time thereafter, the government could take over the property at a fair value, taking into account depreciation, but excluding such intangibles as going concern, good will, franchise value, etc. In case of dispute as to a fair valuation the courts would decide.

At the discretion of the Secretary of War, it may be stipulated in the grant that the grantee shall pay the government an annual rental, and at the end of 20 years and every 10 years thereafter the charges may be readjusted. While the wisdom of charging for such privileges has often been questioned, since they are usually passed on to the consumer in the form of higher rates, still it is well to give the Secretary of War this power, to invoke as special conditions may warrant.

In leasing the use of surplus water from dams constructed by the Government for purposes of navigation, preference is to be accorded to municipal projects or other corporations not operated for private profit. Moreover, it is specifically stated that no rights under this act shall be owned or controlled by any combination in the form of an unlawful trust to limit the output or sale of electricity. Violation of this provision will mean forfeiture of the grant. However, the Secretary of War may approve of interconnecting systems for economically handling loads providing the energy is properly accounted for.

The regulation of service and rates is left to the states, except in the matter of interstate business or where adequate state regulation is not provided; in such cases this duty falls upon the Secretary of War, who in fixing rates shall not consider intangible values.

None of the provisions of the Adamson bill are intended to apply to any water-power grants on public lands of the United States under the jurisdiction of the Department of the Interior or the Department of Agriculture.

Opponents of the bill argue that at the end of 50 years, should the Government desire to regain possession of a water power, it would have to take over the whole system served. Moreover, they point to no provision for publicity of accounts, although, it is clearly specified that all books shall be open to inspection by the Secretary of War or his duly authorized agents.

While we believe the Government should encourage the cheap production of power, there are several cases at present in which a large part of the hydro-electric energy is sold to a steam-operated system and the steam power determines the price to the consumer. There is apparently nothing in the bill to prevent this, in which case relief would have to be sought through the state commissions.

Although not ideal, we are inclined to believe that the merits of the bill as it now stands outweigh its defects. Although it might appear to place too much power in the hands of the Secretary of War, yet, viewed from another angle, this is desirable in that it fixes responsibility and such an official who violated this confidence would have to account to the public.

CO_2--A Tool

Many engineers and firemen seem worried because they think they do not understand what CO_2 is. They are told that it is a gas consisting of one atom of carbon and two of oxygen, but this explanation is not enough; it is not satisfying. To such men there is a chemical mystery about the whole thing which they feel they should understand to the fullest if they are to get the most out of a pound of coal.

The technical press, engineering organizations, educational work, conversations among power-plant men, all have treated of the gas CO_2 until it would seem that the relation of this gas to boiler-room practice was common knowledge even to coal passers. In reality, however, the effect of all this published and talked-about matter has been to confuse many operating men, just as one gets confused trying to miss nothing at a three-ring circus.

It is no more necessary to the best results from the burning of coal in a boiler furnace that the fireman shall understand all there is to the chemistry of the flue gases, than it is essential for a gardener to have a thorough knowledge of the scientific aspects of heat and light in order to successfully grow plants or vegetables in a hothouse. When one looks at a steam-pressure gage he has in mind pressure; he does not worry if the steam whose pressure is indicated or being recorded is dry saturated or superheated, or whether the entrained water in it is acid or alkaline.

Pressure is the thing we want to know about, and on its amount as compared with what it should be we can locate troubles indicated by an increase or decrease.

In this case, we use pressure as a tool, so to speak; and that is the way to use CO_2 readings on the burette of an Orsat or the chart of a CO_2 recorder. The all-important thing to know is that, if the boiler can be worked as hard as desired and 10 to 15 per cent. CO_2 maintained in the flue gases at the uptake, the combustion is good. A man who had made ever so thorough a study of chemistry and CO_2 in particular could get little or no better results in coal consumption per pound of water evaporated than if he knew only the above simple fact. If the CO_2 readings are low—and readings below 8 per cent. may be considered low—then the furnace is getting too much or too little air—usually too much. Whether too much or too little, it is easy to find which it is, and any man with normal reasoning power and common boiler-room experience will soon ascertain why it is too much or too little. The CO_2 readings are merely a means to this end. They tell him which way he is going, whether his firing and combustion-control methods are for better or for worse, and this is the chief thing in boiler-furnace practice.

The more a man knows about boiler practice the better use he can make of CO_2, and the more he investigates to find out why CO_2 readings are high or low, the better he will know how to run a boiler.

⁂

Combining Flood and Power Dams

In a recent editorial, the *Dayton News* questions the wisdom of omitting power development in connection with the proposed reservoirs for flood protection in the Miami Valley. An account of the Wolfelsgrund Dam in Prussian Silesia, printed in the *Engineering Record* for May 30 is cited as one in which the dual purpose of flood prevention and power development are successfully combined. An editorial in the same issue of the *Engineering Record* is also quoted as follows:

> It is plainly an error to dismiss the possibility of a dual purpose dam without adequate consideration.

The *News* failed to quote, however, what the *Record* said in the forepart of the same editorial:

> Contrary to views frequently expressed in this country, the construction of double-purpose dams is not necessarily an engineering mistake.

This does not say, however, that it is frequently possible to combine the two functions in one dam.

Much as we are interested in the development of water power, we are compelled to admit that there are more cases where the two functions cannot be combined than where they can be, and this is better understood when it is considered what the two functions are and how incompatible they are.

The purpose of a flood dam is to hold back the water in time of heavy rainfall to a rate of discharge that is not productive of damage; but the aim is to get rid of the water as fast as it can be discharged safely, so that the dam may be in readiness for the next flood without being unnecessarily large.

A power dam, on the contrary, is for accumulating water during the rainy season against the time when the stream flow is at its lowest ebb, and thus keep the flow as near as possible to its average value throughout the year. Naturally, if a flood came during the time that the reservoir was full, there would be no flood protection. The situation would be just as bad as though there were no dam, so that for the dam to combine the two functions it would have to be probably twice as large as it would for either purpose alone.

Where there is no trouble from floods, dams can be built for power purely, but where there is flood difficulty it is quite a question if the power feature should enter in, on account of the greatly increased cost.

It is impossible to deal in generalities in questions such as this; they must be settled for each specific case. If sufficient head can be secured and sufficient power developed to warrant the expenditure for the land which must be condemned and the type of dam which must be constructed, then the dual-purpose dam is justified, but only then.

A flood dam is a benefit to any power developments lower down in the valley, if there are any, in that it saves to them a lot of water which would be wasted if it came down in time of flood, because of being in excess of the quantity they could handle; but how much this benefit amounts to, depends on the capacity of the flood reservoir, and how long it holds back the surplus water; in other words, how nearly it maintains an average flow.

While the *Engineering Record* is doubtless right in saying that it is an error to dismiss the possibility of the dual-purpose dam without adequate consideration, it is also plain that the "adequate consideration" needs emphasis, for it is a decided mistake to undertake the construction of a dam to combine both purposes without carefully weighing all questions bearing on its utility and cost.

⁂

Proper Tube Expanding

A most important subject is treated by an authority on page 245 of this issue. Too much stress cannot be put on the need of the utmost care in expanding the tubes into boiler drums and headers. Where possible it is always better to have the work done by an expert boiler maker; large plants usually have one on the payroll and small plants should call one in when needed. However, emergencies may arise when the job must be done without expert help, and, in any event, it is well for anyone having to do with boilers to know how the work should be done whether he has to do it himself or not. No matter how familiar such a one may think himself with the proper method of tube expanding, we earnestly recommend that he read the letter by Mr. Wells, not once but as many times as may be necessary to thoroughly understand the how and the why of the directions given. Finally pass it around the plant or post it where "he who runs (the boilers) may read."

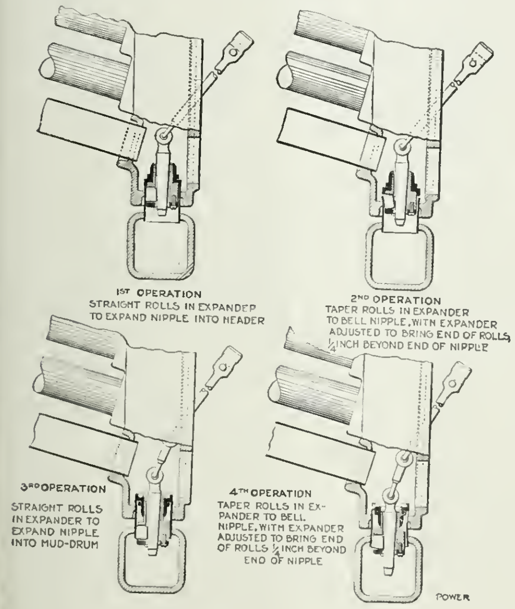
⁂

The annual report handed to the chief engineer of power plants of the Boston Elevated Railway Co. shows a coal consumption of 1.744 lb. per kw.-hr. for last year, (year ending June) total output from the South Boston Station. This figure allows for all losses. Who is getting better results?

Correspondence

Proper Tube Expanding

The issue of June 9, page 838, described an explosion at the plant of the Detroit United Rys., New Baltimore, Mich. A wrought-steel mud drum blew off the nipples, according to the article, due to the tube holes in the mud drum being somewhat tapered, which condition was brought about by the use of a worn and somewhat tapered cutter.


1ST OPERATION
STRAIGHT ROLLS IN EXPANDER TO EXPAND NIPPLE INTO HEADER
2ND OPERATION
TAPER ROLLS IN EXPANDER TO BELL NIPPLE, WITH EXPANDER ADJUSTED TO BRING END OF ROLLS 1/4 INCH BEYOND END OF NIPPLE
3RD OPERATION
STRAIGHT ROLLS IN EXPANDER TO EXPAND NIPPLE INTO MUD-DRUM
4TH OPERATION
TAPER ROLLS IN EXPANDER TO BELL NIPPLE, WITH EXPANDER ADJUSTED TO BRING END OF ROLLS 1/4 INCH BEYOND END OF NIPPLE
POWER

Instructions for Expanding Tubes

As soon as we learned of this accident, the Babcock & Wilcox Co. sent an engineer to New Baltimore, and found, first, that the mud drum was put in place by employees of the Detroit United Rys. on or about Mar. 20, 1914; second, that the expander used was equipped with straight rollers only; third, that the ends of the nipples did not extend properly through the tube seats of the mud drum and were not flared; fourth, that in expanding these nipples, the lower ends of the expander rolls did not pass through the nipple seats, and that it was this operation which caused these seats to become tapered.

The accompanying sketches show the proper way of expanding mud-drum nipples, and also give explicit directions. One expander and both straight and tapered rolls are required. There are four operations:

First—Expand the nipple into the header. Use straight rolls centered at the header seat.

Second—Bell the nipple in the header. Use tapered rolls adjusted to bring the ends of the rolls $1/4$ in. beyond the end of the nipple.

Third—Expand the nipple into the mud drum. Use straight rolls centered at the mud-drum seat.

Fourth—Bell the nipple in the mud drum. Use tapered rolls adjusted to bring the ends of the rolls $1/4$ in. beyond the end of the nipple.

We shall be glad if you will publish this letter, together with a cut, as such publication will give to your readers correct information in regard to this most regrettable accident, and, in addition, may be the means of preventing similar accidents in the future.

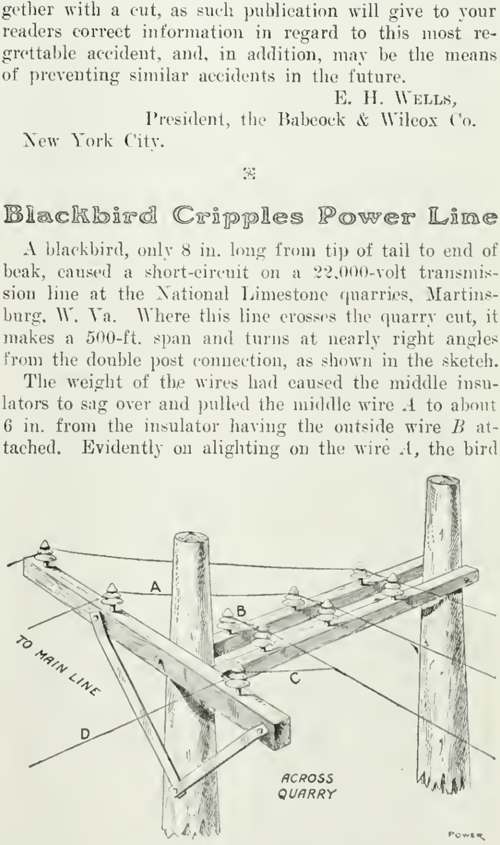
E. H. Wells,
President, the Babcock & Wilcox Co.
New York City.

⁂

Blackbird Cripples Power Line

A blackbird, only 8 in. long from tip of tail to end of beak, caused a short-circuit on a 22,000-volt transmission line at the National Limestone quarries, Martinsburg, W. Va. Where this line crosses the quarry cut, it makes a 500-ft. span and turns at nearly right angles from the double post connection, as shown in the sketch.

The weight of the wires had caused the middle insulators to sag over and pulled the middle wire *A* to about 6 in. from the insulator having the outside wire *B* attached. Evidently on alighting on the wire *A*, the bird had rocked to get its balance and came close enough to cause the current to jump the remaining distance, causing a short-circuit, which continued to burn after the bird had dropped off, until about 2 ft. of wire was consumed. Wire *B*, which is the dead end of the first wire crossing the quarry, is wound on the two insulators with a figure 8, and was burned in two, it being held up only by the connection to wire *D*.



Right-Angle Turn of Transmission Line

This power line furnishes electricity to about 1040 hp. of motors and the short-circuit also caused the shutdown of two other plants connected in parallel with it; the latter for only a few minutes until the main-line switches could be thrown, cutting out the disabled line. It took about two hours to repair the burned wires.

The old saying that troubles never come singly proved true in this instance, as a few hours later a steam pump blew out a plug in the water end and drenched the motor which was driving a centrifugal pump, causing it to burn out two coils in the field before the fuses blew. Three hours more were lost in cutting out the burned coils and putting in jumpers. The pump is now running the same as before minus two coils.

C. L. Mallery.

Martinsburg, W. Va.

Brass vs. Babbitted Bronze Boxes

I think Robert P. Harris is right in his letter on page 861, June 16. The edges *CC*, Figs. 1 and 2, should have been filed or planed off evenly until the brasses were a nice fit to the crankpin, and the shims *BB*, Fig. 3, put in each side of the brasses to keep the distance between the centers the same.

Babbitted iron boxes are used on some stationary engines, but if the iron comes in contact with the pin it will be badly scored before the engine can be stopped. To prevent cutting the pins, babbitt-lined boxes are used, but they are often found too soft for good service, and wear away rapidly under heavy overloads. Babbitted brass or iron boxes are much cheaper in first cost than bronze. They may be fitted to the pin by free use of oil to keep them from getting too hot while running only a few hours at a time until it bears evenly all over, when it will then cool down, and after being taken out and the edges trimmed it will give no further trouble.

There are conditions in some plants where it means much damage if the machines cannot be freed from the stock that is going through before they are stopped. What would happen to a cold-storage plant if the compressor had been stopped suddenly without being pumped out, as in the case of a hot crankpin if the ordinary babbitted brass or iron box was used?

The bronze boxes illustrated in Figs. 1 and 2 will prevent such possibilities. Phosphor bronze is used on the crosshead pins and babbitted bronze on the crankpins and bearings of large engines and compressors. Bronze wears well on the crosshead pins, but being made of copper and tin, is too hard for either crankpin or main bearings without being babbitted. The babbitt equals about two-fifths of the surface, which causes the bearing to run with less heating. The brass box is made of copper and zinc, and is much softer and not suitable where the engines must be kept running after the babbitt has been melted out. The ideal bronze has a temper midway between phosphor bronze and brass.

Most engineers object to using either bronze or babbitted bronze boxes, because they must be kept keyed up closely, for with the same amount of slack they will make more noise.

When a bronze box is put on, the pin should be smooth and true, the box fitted perfectly, and the engine in perfect alignment. The high spots on the bronze surface cannot be worn off by running the engine. For this reason, it requires a skilled mechanic to fit them, and they must have a liberal supply of good oil until worn down to a good running fit, which may require a week or more.

When well taken care of, there are no better running boxes, and they will last a life time when properly fitted, if they get enough good oil. Most bearings wear or are melted out through being keyed up too tight, gathering grit or having insufficient oil. I prefer not to use oil channels; they collect dirt and, when filled, cause heating. Less oil will be thrown from the bearings when they are run brass to brass as in Fig. 3, at *AA*, enough being filed off the edges to allow the bearing surfaces to just fit the pin. Keying up tight in this way prevents wear on the rod end and avoids many hot boxes. The choice of methods in fitting boxes is usually left to the engineer. Many stationary-engine builders make boxes with a clearance at *AA*, to allow keying up in a few minutes, while the marine engines have a bolted stub end with removable shims *HH*, Fig. 4.

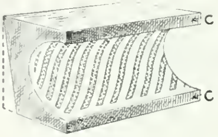


FIG. 1
BRONZE BOX WITH INLAID RIBBON FORM OF BABBITT

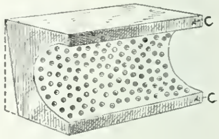


FIG. 2
BRONZE BOX WITH BUTTON FORM OF BABBITT

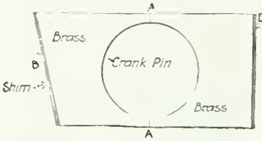


FIG. 3
A CLOSE FIT, BRASS TO BRASS

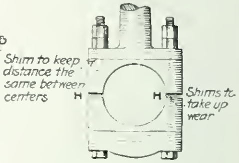


FIG. 4
MARINE END ROD WITH SHIMS

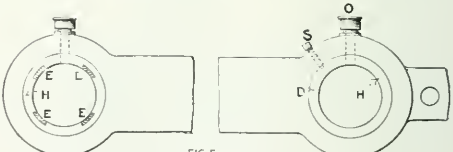


FIG. 5
LOCOMOTIVE CONNECTING ROD USED BETWEEN DRIVES

Types of Babbitted Boxes

In this type, when the wear equals the thickness of one shim, it is removed and the bolts tightened up. Shims can be used at *AA*, Fig. 3, but in some cases the bearing edges of the brasses are not of sufficient area to clamp them in so that running brass to brass holds the box more rigidly. I have run engines with bronze boxes like Figs. 1 and 2, both with and without oil grooves. When they get hot I use a little graphite or flour of sulphur to keep them from cutting and to smooth up the bearing surfaces. White lead will help when nothing better is at hand. Much depends on the system of oiling.

In some cases, such as on locomotives, it is impossible to get extra oil on the pins while running, and the engine must be kept running to reach a siding. Only a few locomotives have adjustable boxes on the rods. They are generally solid ends with babbitted bronze boxes, forced in the rod ends under pressure and held by setscrews; they are made in the form of bushings. Fig. 5, *D*, is the bushing, *S* the setscrew, *O* the grease cup; and *EEEE* the babbitt. They are so made because each time a box is keyed it changes the rod length between centers and causes strain when the pins are passing the centers. Hence they will heat, even though they may be loose on the pin. If the locomotive bearings were fitted nicely, as for stationary service, they would heat in a short time and melt the babbitt. With the solid end rod and the bushing type of box, this does not often happen. When worn, the bushings are replaced with new ones.

Some stationary engineers recognize the advantage of the brass-to-brass method of operation, and remove the boxes and file off the edges each time they are taken up. I am still using the bronze babbitted boxes which were originally furnished with the engine. I prefer the button type of babbitt, as it wears much longer, runs smoothly, and is easy to keep tight on an overloaded engine.

R. A. Cultra.

Cambridge, Mass.

Babbitt bearings are good in places where a continuous supply of oil is impossible, for the reason that, should the wearing surfaces get dry, the babbitt will wear without much increase in friction; and further, in case the bearing gets so hot that the babbitt will run, the journal is in no danger of getting injured. A bronze bearing, however, properly made, fitted and lubricated, will outlast a babbitt bearing under the same conditions.

Some claim that babbitt has a lower coefficient of friction than bronze. While this is not true with some bronze, it does not make a particle of difference if the coefficient of friction of the babbitt is lower, for in a well-lubricated bearing, the metal surfaces do not touch. Therefore, the friction of the bearing will depend on the coefficient of friction of the lubricant. Friction being the direct cause of heat, a bearing will heat either on account of an insufficient supply of oil, or due to the oil not having enough body to withstand the load.

An oil-groove on each side of the crank brasses will form two pockets and there is no danger of the oil being squeezed out.

With this method of fitting brasses, there is no need of other oil grooves in either of the brasses to aid in distributing the oil, as the motion of the crankpin distributes the oil far more effectively.

Samuel L. Robinson.

Vera Cruz, Mex.

It seems to me that those brasses were not properly fitted to the pin or that the engine was out of line, otherwise there should have been no trouble. It is my experience with this metal for bearings that if the brasses fit correctly and the parts are in line, one can get along well with them. We have always thought they were more likely to heat than babbitt. A babbitt bearing has a tendency to form itself to fit the journal, especially if the pressure is heavy or it warms up somewhat.

The one serious fault with the brass bearing is that, if it gets hot, it generally damages the journal. Cast iron is an ideal bearing metal if kept properly lubricated.

A case-hardened journal works well with brass bearings; if kept well oiled, there is but little wear or trouble. We have a gas engine, which has a 6-in. diameter, case-hardened and ground wristpin, which gives entire satisfaction with brass boxes. This engine once wore the pin (not case hardened) and brasses about $\frac{1}{16}$ in. per 10-hr. run on as nice a pin as ever went into an engine. Another gas engine, with overhung cranks and brass boxes, used to get hot, which often was not the fault of the bearing metal. Sometimes the pins would get loose in the cranks, and at other times the oil would fail. As we visited it only about once an hour it had time to get as hot as it felt like. When we found it smoking, we would feed water through the oil piping until it had cooled somewhat. We would then feed in a quart of oil and sapolio, put the oil cup on, set the feed lively, and let it go at that. Incidentally, I do not believe in putting sapolio or anything of that nature in a good bearing. About the best lubricant I have ever used for a "bad actor" is cylinder oil and white lead mixed together.

Why do the valve-gear bearings on a steam pump wear so rapidly? Some say the oiling is neglected. Now, I have made it a point to see that the gear was well oiled, but the wear went on just the same. Possibly, the bearing pressure was too great.

We operate an air compressor that sometimes develops a knock in the cylinder. It is a single-stage machine compressing to 80 lb. The knock is caused by carbon baking on the unjacketed heads, especially the upper part, where the discharge valves are, thereby filling the clearance space.

J. O. Benefiel.

Anderson, Ind.

I have used solid brass boxes on small pins up to 3½ in. in diameter where the rod was of the marine type, but in every case the pin was badly cut. I am opposed to brass boxes for crankpins, because they produce greater friction. If the oil supply should fail, the pin and boxes may be badly cut, while with babbitt lining the babbitt will melt out without doing any serious damage to the pin. In this case, I believe that in time the brass boxes could have been made to run with some degree of success, but the babbitt-lined boxes gave so much better results that there was no reason to change.

Once I used brass boxes on the crankpin of an air compressor in preference to babbitt for the sole reason that the compressor was in an isolated part of the mill, and frequently the oil cups would run empty (it was oiled by the millwright's helper, who was sometimes busy on other work and forgot it), in which case it would get hot, grip the pin and throw out the circuit-breaker. With babbitted boxes it was usually necessary to put in a set of new ones as the babbitt would be melted out; with brass it was necessary only to cool them off and put on some oil. Later, grease was substituted for oil, which prevented further trouble.

J. C. Hawkins.

Hyattsville, Md.

I am using bronze boxes on the crankpin and on the wristpin end of the rod on an oil engine of the trunk-piston type. The crank boxes are marine, the piston end is a solid stub with a wedge and bolt, and is open to admit of adjustment, but the crank boxes are brass to brass. These boxes have been in service six years, and have been taken apart three times only, to examine the piston rings. We have never dressed off either one and there is no knocking.

J. P. Colton.

Ohio City, Ohio.

Human Element in Coal Sampling

I was much interested in the editorial on coal sampling in the July 21 issue. As to the relative merits of intelligent and ignorant men as coal samplers, both classes have their weaknesses. The intelligent man, especially if he is to be affected by the outcome of an analysis, either financially or otherwise, is likely to give way to his prejudices; on the other hand, the ignorant laborer is likely to possess a little knowledge, which, according to the adage, is a dangerous thing.

A few weeks ago I collected a coal sample for analysis and the crushing in the preparation of the sample was intrusted to an Italian laborer. Upon returning a half hour later I was surprised to find that the laborer had carefully picked out and laid aside a number of large pieces of slate. When asked his reason for doing this, he said: "Slate no good; no burn." I have observed this same tendency in laborers employed as coal samplers several times. They are likely to come to the conclusion that coal which the boss needs for some special purpose should be carefully selected, and that slate and bone, being worthless, should be rejected.

In taking or preparing a sample of coal for analysis, I would prefer to intrust the work to a man who understands its purpose, after instructing him in the importance of taking the sample entirely without prejudice. This work is just as important as the analysis itself and deserves intelligent attention, coupled with strict honesty.

"Business honesty," as one of Power's recent editorials calls it, applies as much to the boiler room and the laboratory as to the policy of a manufacturer or grocer. The power plant is buying heat in the form of coal, and selling or using power, and the owner or engineer should feel it his duty not only to get that for which he pays, but also to pay for that which he gets. The coal weights, the sampling and the analysis are all parts of the "scale" which weighs his purchases, and this "scale" should carry no false weights. Honest quality in fuel is just as important to the power-plant man as are pure food, pure clothes, etc., to the general public.

William A. Dunkley.

Atlantic City, N. J.

Smoke Abatement vs. Economy

Just how great, if any, is the loss due to smoke from boiler furnace stacks? This question as related to the rating under which the boilers are operating when smoky has been too much neglected.

Consider a plant in a locality unprovided with a smoke ordinance and without smoke-consuming devices. In this plant it is desirable to have some smoke at all times rather than to operate with a possible large excess of air. The waste and loss through maintaining the stack clear would undoubtedly be greater than that due to a slight amount of smoke. This particularly holds good in the consumption of liquid fuel.

I have referred to conditions approximating rated boiler capacity. When the reverse is true and the boiler plant is called upon to operate under heavy loads, it has been found impossible to maintain clear stacks, with freedom from smoke, unless the boilers are equipped with smoke-consuming devices. I have found that a higher efficiency can be had by allowing the furnaces to smoke considerably under heavy overload conditions. As the heating surfaces become fouled, the efficiency will drop; then the dusting hose should be used freely on the boilers after they have been operated at very high ratings.

Designers are prone to limit the area and height of stacks too much. After the plant has been completed and put into operation, it is too often found impossible to obtain the draft required to operate the boilers at high ratings without much smoke. Can it be that the designers are afraid the firemen will maintain too high a draft and that the economy will suffer through their ignorance?

If the designers will convince owners of steam plants that it may be profitable to build stacks of sufficient capacity to take care of any condition which may arise, and that it is economy to employ technical men to watch the operation and prevent waste, there would in all probability be much less smoke.

The engineer in charge is usually a man who has served his time in the boiler room as a fireman or water-tender many years since, in the days when economical operation of boilers was not given much consideration.

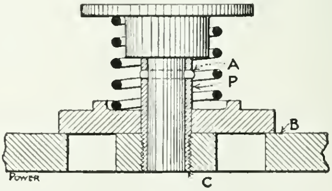
William Plaisted.

Redondo Beach, Calif.

[Many combustion engineers complain because they so frequently find chimneys and stacks too large for the load condition. Also, it seems to be the opinion of most combustion engineers that they would rather coach for the position of head fireman a man who is not, strictly speaking, a technical man.—Editor.]

Pump-Valve Stems Repaired

When several valve studs worked loose, their threads and those in the valve plate were spoiled. A quick-repair job was done by pressing the stems into one-half inch pipe nipples *P* and pinning through both stem and pipe at *A*. The pressure plate *B* was then tapped out to one-half inch pipe size at *C*. This has given better satisfaction than the original, partly on account of the larger size of the stem.



Repaired Valve Stem

Earl Pagett.

Coffeyville, Kan.

Inquiries of General Interest

Dimensions of Tapered Pin—If a tapered pin which is to be finished 4 in. in diameter at the large end, is to taper 1 in. to the foot and when finished is to be 12 in. long what will be the diameter of the small end of the pin when finished?

E. F. T.

The diameter of the small end would be 3 in., for taper is the actual reduction in size, although it is sometimes confused with slope with respect to the axis.

Horsepower Rating of Automobile Engine—What is the formula for the nominal horsepower of automobile engines?

J. E. C.

Their usual nominal horsepower rating is according to the formula

$$hp. = \frac{d^2 \times n}{2\frac{1}{2}}$$

in which d = diameter of cylinders in inches and n = the number of cylinders.

Strength of Rivets in Double Shear—Why are not rivets in double shear considered to have twice the strength of rivets in single shear?

T. M.

Because tests of riveted joints have generally shown that rivets in double shear do not offer twice the resistance of rivets in single shear, which is probably due to unequal distribution of the stress in the two rivet sections when in double shear.

Horsepower-Hours—If an engine develops an average of 50 hp. during 10 hr. and 25 hp. during 14 hr. per day, what number of horsepower-hours would be developed in 30 days?

J. M.

During ten hours each day the development would be

$$10 \times 50 = 500 \text{ hp.-hr.},$$

and during 14 hr. per day the development would be

$$25 \times 14 = 350 \text{ hp.-hr.};$$

hence for 30 days the development would be:

$$(500 + 350) \times 30 = 25{,}500 \text{ hp.-hr.}$$

Patents—Can a patented article be made by anyone for one's own use? If an article is marked "patent applied for," can it be made for one's own use?

A. E. C.

The right to manufacture and use a patented article without liability is limited to experimenting with it only. The intent is to permit research along the same lines and not to grant a privilege without a just compensation. An article for which a patent has been applied, when so designated, is entitled to the same consideration.

Water Heated by Given Quantity of Steam—One thousand pounds of steam at 212 deg. F. is used for heating a building and the condensation is returned to the boiler at 192 deg. F. If the heat given off is applied to raising the temperature of water, how many pounds of water would it raise from 32 deg. to 112 deg. F.?

E. G.

Each pound of steam delivered at 212 deg. F. would contain 1150.4 B.t.u. above 32 deg. F., and as each pound of condensate when returned to the boiler at 192 deg. F. would contain 192 — 32 = 160 B.t.u., the heat transferred to the building per pound of steam used at 212 deg. F., and converted into condensate at 192 deg. F. would be 1150.4 — 160 = 990.4 B.t.u.; or for 1000 lb. would amount to

$$1000 \times 990.4 = 990{,}400 \text{ B.t.u}$$

To raise 1 lb. of water from 32 deg. F. to 112 deg. F. requires 79.93 B.t.u., and, therefore, the 990,400 B.t.u. used for heating the building would be capable of raising

$$\frac{990{,}400}{79.93} \text{ or } 12{,}390 \text{ lb. of water}$$

Plunger Pumps in Series—How much pressure could be pumped against by two plunger pumps each of the same size of steam ends and plungers and each capable of pumping against a pressure of 160 lb., if arranged in series, i.e., with the delivery of one of the pumps connected with the suction of the other?

T. J. C.

Assuming that the pumps are double acting with the plungers on opposite ends connected together and neglecting loss of pressure by friction in the passage of the water from one pump to the cylinder of the other, a plunger of the second pump during its suction stroke would be acted upon by 160 lb. pressure which would be transmitted to the plunger making a discharge stroke. The assistance so rendered would be as much as the pressure exerted by the steam and the pump would be able to work against a pressure of

$$2 \times 160 = 320 \text{ lb. per sq.in.}$$

In case, however, the second pump were a single-acting plunger pump, there would be no such advantage, for although the first pump delivered the water under pressure to the second one, the second one would be employed in maintaining the pressure without capacity or assistance to increase the pressure above 160 lb.

Diameter of Uptake—What diameter of smoke uptake would be equal to the combined areas of tubes of one return-tubular boiler having ninety 2½-in. tubes and another having one hundred 3-in. tubes?

B. V.

The internal diameter of a standard 2½-in. boiler tube is 2.282 in., and its cross-sectional area is

$$2.282 \times 2.282 \times 0.7854 = 4.09 \text{ sq.in.},$$

and 90 tubes would have a cross-sectional area of

$$4.09 \times 90 = 368.1 \text{ sq.in.}$$

A standard 3-in. tube has an internal diameter of 2.782 in. and a cross-sectional area of

$$2.782 \times 2.782 \times 0.7854 = 6.079 \text{ sq.in.},$$

and 100 tubes would have a total cross-sectional area of

$$6.079 \times 100 = 607.9 \text{ sq.in.}$$

The united area of tubes of both boilers, therefore, would be

$$368.1 + 607.9 = 976 \text{ sq.in.}$$

An uptake pipe of the same cross-sectional area would have a diameter of

$$\sqrt{\frac{976}{0.7854}} = 35.2,$$

or practically 36 in. diameter.

Steam from a Cubic Inch of Water—What would be the pressure of a cubic foot of dry saturated steam made by the complete evaporation of a cubic inch of water from 60 deg. F.?

D. L.

At 60 deg. F. water weighs 62.37 lb. per cu.ft., hence the steam generated from a cubic inch of water would weigh

$$\frac{62.37}{1728}$$

or about 0.0361 lb. Referring to Marks and Davis steam tables giving the density of steam at various pressures, it will be seen that the weight of 0.0361 lb. per cubic foot comes between 0.03597, which is the density or weight per cubic foot of steam at 14.13 lb. per sq.in. absolute pressure, and 0.03664, the density at 14.41 lb. absolute. The given weight per cubic foot would, therefore, be

$$0.0361 - 0.03597 = 0.00013 \text{ lb.}$$

greater than at 14.13 lb. absolute. As with an increase of pressure from 14.13 to 14.41 lb. absolute, the density increases at the rate of

$$\frac{0.03664 - 0.03597}{14.41 - 14.13}$$

or 0.00239 lb. per pound increase in pressure, than when the density became equal to 0.0361 lb. per cu.ft. the pressure for that density would be found by interpolation to be

$$14.13 + \frac{0.0361 - 0.03597}{0.00239} = 14.18 \text{ lb. absolute.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics—XXII

Last Lesson's Answers

96. As 1 gal. of water weighs about $8\frac{1}{3}$ lb., the total mass of water raised is

$$1000 \times 8\frac{1}{3} = 8333\frac{1}{3}\ lb.$$

Since this amount of water is lifted 120 ft. in one minute, the work done equals

$$8333\frac{1}{3} \times 120 = 1{,}000{,}000\ ft.\text{-}lb.$$

and the horsepower required to do this work is

$$\frac{1{,}000{,}000}{33{,}000} = 30.3\ hp.$$

97. The work done in the water end of the pump is equal to 30.3 hp. If the efficiency between the steam and water ends is 70 per cent., then the horsepower required in the steam end is

$$30.3 \div 0.70 = 43.3\ hp.$$

98. Twenty tons of coal equals

$$2000 \times 20 = 40{,}000\ lb.$$

The vertical distance the coal is raised is 150 ft. From equation (52)

$$Hp. = \frac{F \times S}{T \times 33{,}000}$$

In this problem $F = 40{,}000$ lb., $S = 150$ ft. and $T = 60$ min., hence the horsepower required is

$$\frac{40{,}000 \times 150}{60 \times 33{,}000} = 3\frac{1}{3}\ hp.$$

This answer holds true on the assumption that the engine is hoisting continuously for the entire hour. As an actual fact, such is not the case, as allowance must be made for the loading and lowering of the bucket, so that the actual time of hoisting is considerably less than one hour, and hence the horsepower required will depend upon the rate at which the bucket is being raised in feet per minute.

99. Potential energy is weight times vertical distance above a given reference plane. Here the weight is 1000 lb. and the distance is 95 ft., hence the potential energy is

$$95 \times 1000 = 95{,}000\ ft.\text{-}lb.$$

100. The kinetic energy of the body is $\frac{WV^2}{2g}$. To determine this energy it is necessary to find the velocity V which the body has after it has fallen the vertical distance of 95 ft. This may be found from equation (43), where $V^2 = 2\ gH$, or

$$V = \sqrt{2\,g\,H} = \sqrt{2 \times 32.16 \times 95} = \sqrt{6102} = 78.2\ ft.\ per\ sec.$$

Substituting this value of V in the equation for kinetic energy there results

$$K_e = \frac{W\,V^2}{2\,g} = \frac{1000 \times 78.2 \times 78.2}{2 \times 32.16} = 95{,}000\ ft.\ lb.$$

Energy (*continued*)

Problems 99 and 100 illustrate the fact that potential energy may be changed into kinetic energy by allowing the object to fall through the vertical distance above the given reference plane, or, as commonly expressed, by converting "head into velocity." This may be shown more clearly by comparison of the equations for potential and kinetic energy. Thus

$$K = WH$$

$$\text{and } K_e = \frac{W\,V^2}{2\,g}.$$

From equation (43)

$$V^2 = 2\ gH$$

$$\text{or } H = \frac{V^2}{2\,g}.$$

Substituting this value in the equation

$$K_e = \frac{W\,V^2}{2\,g},$$

there results

$$K_e = WH$$

which is the same as the expression for potential energy.

Moreover, *the total amount of energy in the body remains constant and is equal to the sum of the kinetic and potential energies.* In problem 100, had the body fallen only 47½ ft. its total energy would still have been 95,000 ft.-lb.; only 47,250 ft.-lb. would have been kinetic and 47,250 would have been potential energy.

Equation (57) shows that energy may be converted into useful work, and *vice versa;* but in no case is it possible to destroy or annihilate energy. This gives rise to the law commonly called the *"Conservation of Energy,"* which may be summed up in the following three statements:

(1) *The sum total of the energy in the universe remains constant.*

(2) *Energy may be converted from one form to another.*

(3) *Energy cannot be destroyed or annihilated.*

The first statement may not be evident at first sight. In a steam engine, due to improper lubrication, unlagged cylinders and poor materials, the efficiency may run very low and the engineer will say there is a loss of power. This statement is true as far as the performance of useful work is concerned, but there is no loss of energy. The steam by virtue of the energy it possesses does several things in the engine cylinder; first, it must overcome all frictional losses; second, it must heat up the cylinder, and, last of all, it must overcome the external resistance or load on the engine. Hence the energy in the steam is all accounted for and there is no loss, but simply a conversion of one form of energy into several other forms. Whatever energy may be lost in one form is sure to appear in a different form, so that the sum total of the energy of the universe remains constant.

That part of the energy of the steam which is not converted into useful work is called *"dissipated energy."*

The second part of the law has already been referred to, that it is possible to change energy from one form to another. This change is universal and is taking place continuously. The human being eats food to provide him with muscular energy which enables him to cultivate his fields and produce more food, which in turn is converted into muscular energy, and so the process continues. The ambition of the modern power plant engineer is to convert the heat energy resident in coal into electrical energy with as little loss as possible. Thus far his efforts have resulted in converting about 18 per cent. of the heat energy in the coal into the electrical form of energy. The introduction of the internal combustion engine is destined to raise this figure to a much higher value.

The third part of the law states that energy can never be lost. This is best illustrated by considering the action of the sun—the main source of the earth's energy. In the early ages the sun supplied the energy to plant life, which gradually developed into trees and into great forests. These in time perished and were buried deep in the earth, and after many years appeared in the form of coal, the energy of which may be liberated by combustion. Part of the coal's energy is transformed into work and the remainder is dissipated in various forms, but none of it is ever lost.

The sun by virtue of the energy it possesses raises the water from the level of the sea to the highest mountains, and as the water flows down from these elevations it becomes possible to convert its potential energy into kinetic energy, which may be utilized to operate waterwheels and turbines.

HEAT

Perhaps the most common form of energy is that known as *heat,* to which reference has already been made. For many years scientists were puzzled as to the form and nature of heat. Some considered it as a substance that had weight; but it remained for the simple experiment of rubbing two pieces of ice together to prove that heat is simply a form of molecular energy. As the molecules of the body move faster and faster, their kinetic energy becomes greater, and the sum total of all their energies constitutes what is known as heat.

The commonly accepted unit of heat is the *British thermal unit,* which is the amount of heat required to raise the temperature of 1 lb. of water 1 deg. Fah., assuming the water to be at its greatest density, which is about 39 deg. F. Recent experiments have proved that the British thermal unit commonly indicated by the letters B.t.u. is equivalent to 780 ft.-lb. of work. A pound of coal contains about 13,000 B.t.u. If all the heat in the coal could be transformed into work there would result 13,000 × 780 = 10,140,000 ft.-lb., and if the heat was liberated in one minute the equivalent horsepower would be

$$\frac{10{,}140{,}000}{33{,}000} = 307.$$

Example—Under certain conditions it takes 1050 B.t.u. to convert one pound of water into dry steam. If all the heat in the pound of coal could be transferred to the water, how many pounds would be evaporated for every pound of coal burned? The number of pounds of water evaporated per pound of coal will equal $\frac{13{,}000}{1050}$ or 12.4. In actual practice, only about 80 per cent. of this figure is realized. One horsepower is equivalent to 33,000 ft.-lb. per min., which expressed in B.t.u. equals $\frac{33{,}000}{780}$ or 42.3.

The figure 780 is called the mechanical equivalent of heat since it expresses the relation between the units of different forms of energy.

If one pound of coal were burned in one minute the horsepower equivalent to the heat energy in the fuel would be $\frac{13{,}000}{42.3} = 307$, or if the coal was burned in one hour the horsepower equivalent would be $\frac{307}{60}$ or about 5. A boiler horsepower is equivalent to about 13 engine horsepower, so that the burning of one pound of coal per hour is capable of producing about $^{5}/_{13}$ boiler horsepower. Hence, to secure one boiler horsepower it is necessary to burn $^{13}/_{5}$ or $2\frac{3}{5}$ lb. of coal per hour. This of course is the theoretical value. Under average conditions one boiler horsepower will be secured by the combustion of 3½ to 4 lb. of coal per hour.

STUDY QUESTIONS

101. What three quantities determine the amount or quantity of heat in a given mass of material?

102. Explain the meaning of the term 1 deg. F.

103. Does the amount of heat required to change the temperature of water 1 deg. F. remain constant as the temperature of the water increases?

104. A certain coal averages about 12,000 B.t.u. to the pound. Find the horsepower equivalent to the combustion of 1000 lb. of coal per hour, assuming all the heat energy in the coal to be liberated during combustion.

What would be the equivalent boiler horsepower, assuming that 13 engine horsepower equal one boiler horsepower?

NOTE—A boiler horsepower is the evaporation of 34½ lb. of water per hour into dry steam at 212 deg. F. from a feed-water temperature of 212 deg. F. To evaporate 1 lb. under these conditions it requires 970.4 B.t.u. The heat equivalent of a boiler horsepower is equal to

$$34\tfrac{1}{2} \times 970.4 = 33{,}479 \textit{ B.t.u. per hr.},$$

or 558 B.t.u. per min. An engine horsepower is equal to 42.3 B.t.u. Therefore the boiler horsepower is equal to $\frac{558}{42.3}$ or 13 engine horsepower, approximately. As the efficiency between switchboard and coal pile is about 6 per cent., it is to be noted that one boiler horsepower under working conditions produces just about one engine horsepower.

105. In problem 104, if it takes 1050 B.t.u. to evaporate one pound of water, how many pounds would be evaporated under the given conditions, assuming that 80 per cent. of the heat in the fuel is transferred to the water in the boiler?

⁂

More Magic Compound Fakers—There has recently been put upon the market in Germany quite a flood of preparations for the purpose of making a brew in which coal or coke is to be wetted before being put upon the fire. The alleged result of using these preparations is that the coal burns more readily and that there is a great saving in the amount of fuel required. Herr T. Oryno, of the laboratory of the Berlin Fermentation Institute, has analyzed a number of these preparations and found them to consist of various salts such as sulphate of magnesia, sulphate of soda, common salt, nitrate of soda, and so on generally with a small proportion of oxide of iron. He concludes that they cannot have the effects attributed to them.—"The Engineer."

GROUP AT THE CONVENTION OF THE UNIVERSAL CRAFTSMEN

Craftsmen's Convention

The twelfth annual convention of the Universal Craftsmen Council of Engineers was held at Cleveland, Ohio, August 4 to 8, with headquarters at the Hollenden Hotel. There were upward of 200 delegates in attendance, representing more than 300 votes.

The meetings of the delegates were held in the large assembly hall of the hotel and the several committee rooms were conveniently located. On the same floor four large parlors were neatly fitted up for the exhibit of engineers' equipment and supplies. The display occupied sixty booths, which were well attended during the five days.

On Tuesday morning at 11 o'clock the opening exercises of the convention took place, William H. Kennedy, presiding. After the invocation by P. H. Early, grand chaplain, the chairman introduced Frederick Sidlo, Director of Public Service, representing Mayor Baker, who cordially welcomed the convention to the city of Cleveland. Grand Chief Henry C. Senn responded for the engineers. Homer G. Powell spoke interestingly on fraternity, and was followed by Walter S. Cadwell, past grand chief. "The Old Guard" was the subject allotted to Past Grand Chief Robert G. Ingleson, who made a short and pleasing address. An impressive part of the services occurred here when Herbert E. Terry, grand warden, asked the privilege of the floor, and on behalf of the Toronto and Winnipeg councils of Canada presented the grand body a silk English flag. John Cope feelingly accepted the gift and the American and English flags were joined together with a white silk bow.

The meeting then went into executive session, the necessary committees were appointed, and an adjournment was taken until the afternoon business session.

There was a liberal program of entertainment in every event of which the ladies were included, such as theater parties, automobile trips to Luna Park, Euclid Beach Park and through the park system of the city.

On Wednesday evening an enjoyable entertainment was given in Assembly Hall, comprising the following numbers: Miss Doris Siegrist, of Cleveland; H. R. Wunder, of Cincinnati; E. C. Adams, Anchor Packing Co.; Billy Murray and Joe McKenna, of Jenkins Bros.; George E. Andrews and Jack Armour, of "Power."

On Thursday evening there was a moonlight sail on Lake Erie.

On Friday evening a banquet was held at which 300 covers were laid. At the close of the service the toastmaster, Robert G. Ingleson, introduced Henry C. Senn, who gave a short address, followed by Frank Martin, of Jenkin Bros. Fifteen minutes of entertainment was given by Jack Armour.

At the closing session of the delegates the following grand officers were elected for the ensuing year: Henry C. Senn, past chief; William Armstrong, chief; Charles F. Siegrist, assistant worthy chief; Nathan J. Burdick, secretary; Herbert E. Terry, treasurer; Frank M. Townsend, warden; Samuel J. Hunt, guard; P. H. Early, chaplain; O. N. Pomeroy, historian; Frank Conroyd, John Moore and Andrew Bennett, trustees. Immediately preceding the election of officers the annual memorial services were held.

Rochester, N. Y. was selected as the next convention city, in August 1915.

THE EXHIBITORS

American Steel & Wire Co.
Bishop, Babcock & Becker Co.
Buckeye Chemical Co.
C. E. Squires Co.
Cleveland Feed Water Regulator Co.
Cleveland Mfg. & Supply Co.
Consumers Rubber Co.
Crandall Packing Co.
Dearborn Chemical Works,
Diamond Power Specialty Co.
Engineers' Appliance Co.
Federal Graphite Mills
Garlock Packing Co.
Goodyear Tire & Rubber Co.
Greene, Tweed & Co.
Griscom-Russell Co.
Hawkeye Boiler Compound Co.
Hill, Hubbell & Co.
Ingersoll-Rand Co.
Jenkins Bros.
John A. Roebling Sons' Co.
Keystone Lubricating Co.
Lagonda Manufacturing Co.
Liberty Manufacturing Co.
McDonough Regulator Co.
McLeod & Henry Co.
Otis Elevator Co.
Peerless Rubber Mfg. Co.
"Power"
Quaker City Rubber Co.
R. J. Bissett Co.
Skinner Engine Co.
Standard Oil Co.
Standard Waste & Mfg. Co.
Strong, Carlisle & Hammond Co.
The Harmon Feed Water Power Specialty Co.
The Lunkenheimer Co.
The Thompson, Hayes Co.
The V. D. Anderson Co.
The Universal Lubricating Co.
The William Powell Co.
Tomlinson Steam Specialty Co.
Trill Indicator Co.
Union Iron Works
William Patterson Supply Co.
Yarnall, Waring Co.

⁂

Addendum to the Description of the Dime Savings Bank Building Plant

The table of the principal equipment in the plant of the Dime Savings Bank Building, Detroit, Mich., accidentally omitted from the article as it appeared in the last issue, is printed on the next page.

⁂

Canadian Water Power Exhibit—At the Panama-Pacific Exposition in San Francisco next year an interesting exhibit in the Canadian building will include a series of models of typical water power plants from the Atlantic to the Pacific. These will be arranged in a semicircle in front of a painting 75 feet long by 9 feet high, presenting a birdseye view of the whole Dominion, with all the known water powers indicated, whether developed or not.

uncil of Engineers, Cleveland, O., August 4 to 8

PRINCIPAL EQUIPMENT OF DIME SAVINGS BANK BUILDING PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling type S special	350 hp.	Generate steam	150 lb. pressure, no superheat	Babcock & Wilcox Co.
4	Stokers	Taylor, three-retort		Boiler furnace	Mechanically operated	American Engineering Co.
1	Traveling bucket	Monorail	900 lb.	Coal from bunker to boiler	Motor driven, Howe suspended scale	Yale & Towne Mfg. Co.
1	Fan	"Sirocco"	No. 8	Forced draft to stokers.	Engine-driven, capacity 3600 cu.ft. per min.	American Blower Co.
1	Fan	Steel plate	40x28-in.	Forced draft to stokers	Motor-driven, capacity 3600 cu.ft. per min.	B. F. Sturtevant Co.
1	Engine	Simple vertical	7x8-in.	Drive forced draft fan	230 volt, 150 lb. pressure, 600 r.p.m.	B. F. Sturtevant Co.
1	Motor	Variable speed	60 hp.	Drive forced draft fan		Crocker-Wheeler Co.
2	Meters	Venturi	4x1-in. tube, 2x¾-in. tube	Boiler feed and Holly loop		Builders Iron Foundry
1	Heater	Open	1500 hp.	Heat boiler feed	Exhaust or live steam	Warren Webster & Co.
3	Heaters	Closed	Each 1400 gal. per hr.	Hot water	Exhaust or live steam	Warren Webster & Co.
2	Pumps	Duplex	7½x5x10-in.	Boiler feed	150 lb. pressure, 50 ft. per min.	The Blake & Knowles Steam Pump Works
2	Injectors	U. S.	2-in.	Boiler feed	150 lb. pressure, lift 310 ft.	American Injector Co.
1	Pump	Triplex	5½x8-in.	House pump	Motor driven, 45 r.p.m.	The Deming Co.
1	Pump	Centrifugal, four-stage	2-in.	House pump	Motor-driven, 1100 r.p.m.	Kerr Turbine Co.
2	Motors	Direct current	15 hp. and 20 hp.	Drive house pumps	230-volt, 1100 r.p.m.	Crocker-Wheeler Co.
2	Pumps	Simplex	10x16x16-in.	Vacuum heating system	40 ft. per min.	Warren Webster & Co.
2	Pumps	Centrifugal	4 in.	Sump	Motor driven, 1100 r.p.m.	Yeomans Bros.
1	Refrigerating system	Absorption	30 ton	Restaurant and drinking water	Exhaust steam	Carbondale Machine Co.
2	Pumps	Burnham simplex	6¼x4x8-in.	Drinking water	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
2	Pumps	Burnham simplex	10x6½x12-in.	Brine	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
1	Pump	Burnham simplex	8x3½x12-in.	Aqua	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
1	Pump	Duplex	12x6½x12-in.	Hydraulic money lift and passenger elevator	150 lb. pressure, 50 ft. per min.	The Blake & Knowles Steam Pump Works
2	Water filters	Double filters	8x8 ft.	Purify house-service water		Wm. B. Scaife & Sons Co.
5	Engines	Four-valve	17x27-in.	Main units	150 lb. pressure, 150 r.p.m.	Ball Engine Co.
5	Generators	Direct current	200 kw.	Main units	115-230 volt, 150 r.p.m.	Crocker-Wheeler Co.
5	Lubricators	Force feed.	2 feed	Lubricate engine cylinders	2 strokes per min.	Hills-McCanna Co.
2	Filters	Oil	50 gal.	Filter spent oil		Richardson-Phenix Co.
9	Motors	Direct traction.	Eight 25 hp., one 30 hp.	Elevators	230 volts, 63 r.p.m. max., car speed 550 ft. per min.	Otis Elevator Co.
5	Fans	"Sirocco"	Nos. 6, 7, 8 and 9, one 42-in. Venturi	Fresh air	Motor-driven, 213 to 320 r.p.m.	American Blower Co.
5	Motors	Direct-current	Total 40 hp.	Drive fresh air fans	220-volt, 213 to 320 r.p.m.	Crocker-Wheeler Co.
4	Exhausters	"Sirocco"	Nos. 4, 5 and 6	Exhaust air	Motor-driven	American Blower Co.
4	Motors	Direct-current	Total 22 hp.	Drive exhaust fans	220-volt, 260 to 400 r.p.m.	Crocker-Wheeler Co.
2	Air washers	No. 1	No. 1	Restaurant and bank		Warren Webster & Co.
1	Vacuum cleaner	Rotary valve	4 sweepers	Building service	Motor driven, 350 r.p.m.	American Rotary Valve Co.
1	Motor	Direct-current	15 hp.	Drive vacuum cleaner.	230-volt, 800 r.p.m.	Crocker-Wheeler Co.
2	Air compress'rs	Vertical	6x4½ in.	Compressed air service.	Motor-driven, 500 r.p.m.	Gardner Governor Co.
2	Motors	Direct-current	3 hp.	Drive air compressors	230-volt, 1100 r.p.m.	Crocker-Wheeler Co.
1	Water weigher	Balancing type	20,000 lb. per hr.	Returns from heating system		Willcox Engineering Co.

Canadian Association's Twenty-Fifth Annual Convention

The twenty-fifth annual convention of the Canadian Association of Stationary Engineers was held at Ottawa, Ont., on July 28, 29 and 30. There was a large increase in the number of delegates in attendance over the past few years. The meetings were held in the board room of the Ottawa Amateur Athletic Association Building, and the spacious gymnasium adjoining was conveniently and tastefully arranged for the display of power-plant equipment, under the auspices of the Canadian Supplymen's Association.

The opening exercises of the convention took place at two o'clock on Tuesday afternoon. Executive President Samuel E. Cosford, presiding. After a short address by the president, Executive Secretary August Kastella introduced Mayor McVeity, who cordially welcomed the delegates and their friends to Ottawa. He pointed out the beauties and advantages of the city and warmly invited the company to come again. John E. Robertson, past executive president, responded for the engineers, and Ernest A. Wilkinson, president of the Supplymen's Association spoke for the exhibitors. The delegates then went into executive session and after the appointment of the necessary committees the meeting was adjourned until three o'clock.

At the several business sessions important matters of general interest to the engineers were discussed and passed upon. The reading of the treasurer's report showed the organization to be in a sound financial condition. An important measure was passed by the deelgates in the appointing of a committee to confer with the government board to request the adoption of graded certificates of license, the Government to decide as to the ability of the engineer. At present there is but one certificate issued.

The Ladies Auxiliary met in executive session, and had a successful meeting and new names were added to the list of membership.

The entertainment program included automobile drives throughout the city for the ladies and visits to the Government mint, Rockliffe Park and the residence of the Governor-General of Canada.

On Wednesday afternoon there was a boat ride to Belle Isle Park by invitation of the Supplymen. There was a good program of outdoor sports of all kinds, with prizes for each event. The baseball game between the Engineers and the Supplymen was won by the latter by the score of 11 to 7. A good band of music was in attendance and refreshments were served.

On Tuesday evening a banquet was given by Capital City Lodge at the Russell Hotel, at which 200 covers were laid. After partaking of an appetizing dinner August Kastella, the toastmaster, introduced the following speakers: Mayor McVeity, Comptroller McLean, ex-Mayor Hopewell, Charles Heitzman, A. M. Wickens, M. R. Griffiths, A. C. Pulver, E. A. Wilkinson, George G. Lee, Samuel Cosford, William Merrill, Henry Thompson, Alexander Campbell and B. L. Thompson. An enjoyable entertainment was furnished by Earl F. Heatherington, James E. Fiddes, Foley and Neville and Jack Armour.

At the final meeting of the delegates the following executive officers were elected: Samuel E. Cosford, of Hamilton, past president; Alfred W. Heath, of Hamilton, president; Robert Dyson, of Guelph, vice-president; John Hale, of Hamilton, secretary; William E. Archer, of Toronto, treasurer; William G. Forbes, of Montreal, conductor; Ernest Horan, Owen Sound, doorkeeper. The officers were installed by Past President John E. Robertson. August Kastella, of the Ottawa Association, was the recipient of a past president's jewel. A vote of thanks was given to the Ottawa Board of Trade and also to the local association for their efforts in making the convention a success.

The Supplymen's Association elected the following officers: A. C. Pulver, president; Herman L. Peiler, first vice-president; C. G. Peterson, second vice-president; J. B. Faatz, assistant secretary; James E. Fiddes, chairman entertainment committee; Lewis H. Hager, charman reception committee; Earl F Heatherington, director of exhibits.

Hamilton, Ont., was selected as the next place of meeting in July 1915.

EXHIBITORS

The Dart Union Co.
The Goldie & McCulloch Co.
"The Canadian Manufacturer"
Peerless Rubber Manufacturing Co.
Imperial Oil Co., Ltd.
The H. W. Johns-Manville Co.
Anchor Packing Co.
E. Leonard & Sons
Canadian Allis-Chalmers Co.
Perolin Co. of Canada, Ltd.
McHaughton Grate Bar Co.
Boiler Repair & Grate Bar Co.
Standard Sanitary Manufacturing Co., Ltd.
The James Morrison Brass Manufacturing Co., Ltd.
Jenkins Bros.
Joseph Dixon Crucible Co.
"The Power House"
"Power"
Quaker City Rubber Co.
Canadian Griscom-Russell Co
Cling-Surface Co.
Dearborn Chemical Co.
The Lunkenheimer Co.
H. L. Peiler & Co.
Garlock Packing Co.

At the Canadian Association of Stationary Engineers' Convention, Ottawa, July 28-30

Recent Court Decisions

Digested by A. L. H. STREET

Injury Caused by Backfire of Gas Engine—Liability for injury to the engineer of a stationary gas engine, caused by backfiring through an open intake pipe in front of which he was standing, was sustained by the Wisconsin Supreme Court in the late case of Jahn vs. Northwestern Lithographing Co., 146 "Northwestern Reporter," 1131. In affirming judgment in favor of plaintiff, the engineer, the court decided that the jury was warranted in finding that the employing company did not provide a safe place of employment, as required by the laws of the state, although the location of the intake pipe on a level with plaintiff's face was temporary only, while a test of newly installed equipment was being made.

Duty to Insulate Electric Power Wires—An electric power company cannot escape liability for death of a person, resulting from his coming in contact with a high-voltage wire which the company negligently permitted to remain uninsulated, by showing that similar wires carrying similar currents elsewhere were not insulated, or that insulation would be expensive. (Massachusetts Supreme Judicial Court, Philbin vs. Marlborough Electric Co., 105 "Northeastern Reporter," 893.)

State Control of Navigation—It is beyond the power of a state to grant the right to a water power company to control navigation on a navigable stream In reaching this decision in the case of Long Sault Development Co. vs. Kennedy, 105 "Northeastern Reporter," 849, the New York Court of Appeals said:

> As long as the waters are maintained as navigable, they remain public waters of the state; and as long as they remain public waters of the state, the state is bound to retain control over them in the public interest.

In this case the court adjudged to be unconstitutional a law enacted by the New York legislature in 1907, giving the Long Sault Development Co. the right to maintain dams, etc., in the St. Lawrence River in connection with a power project

OBITUARY

EDWIN F. WILLIAMS

Edwin F. Williams died at his home, 263 West Eleventh St., Erie, Pa., on Tuesday morning, July 28. He had been in failing health for several years and the cause of his death was general breakdown. He is survived by Mrs. Evaline Williams and a daughter, Miss Edwina Williams, who resides in New York.

Mr. Williams was born in Ohio of Quaker parentage, the youngest of a family of eight which moved to a new settlement in central Iowa in 1854. In the latter part of the Civil War he served as private in Company B, Forty-eighth Iowa Infantry. Immediately after his discharge he went on a hunting expedition with two army comrades, out on the Sioux River, which was then on the extreme edge of civilization.

On the advice of an old river engineer, he entered a blacksmith's shop as apprentice, preparatory to a strikers' position on a boat. After serving two years at blacksmithing, he took up stationary engineering. Having worked a while in a machine shop in Cincinnati, he secured his first position as engineer in a small sawmill near Mount Sterling, Ky.

Edwin F. Williams

He worked for two years in a distillery in Bourbon County, Ky. The next season he took charge of a large engine and battery of boilers in Chambers sawmills, at Muscatine, Iowa. After this he served some time as assistant miller in a water-driven flour mill in Winneshick County, Iowa. In 1870, he went into the government service, commissioned as engineer in charge of the engineering department at the new agency for the Cheyenne and Arapahoe Indians, being then established on the north Canadian river, eighty miles north of Fort Sill, Indian Territory.

A year afterward he went to the mining camp of Central City, Colo., and engaged in running and repairing mill and mine engines and other machinery. He then returned to Iowa and began a course of education in the high school at Boonsboro. Graduating from this school, he entered the State University at Iowa City, paying particular attention to those branches of learning which would aid him in his future engineering work. Running out of funds, he returned to Central City and took up the old work, and at this time he began to invent things, his first work being a friction clutch for mine hoists.

Securing a patent and some financial assistance, he made a trip to Philadelphia and attended the Centennial Exhibition in that city in 1876. Here he first saw Charles T. Porter, for whose wonderful work he had a sincere admiration which never lessened. Not being able to make satisfactory arrangements for the manufacture of the friction clutch, he went to Council Bluffs, Iowa, and there, with the pattern maker at the Council Bluffs Iron Works, he designed a semi-portable hoisting engine, using the Williams clutch for engaging and disengaging the winding drum without stopping the engine. One was built and was a success. The Council Bluffs Iron Works, represented by The Hendrie & Bolthoff Manufacturing Co., of Denver and Central City, Colo., took up the manufacture and sales on a royalty. A large number of these outfits was sold, but, by a technicality, the royalties were not collectible after the first few.

Mr. Williams then took up his real life work, the study and development of the steam engine. After some five years' experience as erecting engineer and expert for Hill, Clark & Co., Boston; the Hartford Engineering Works, Hartford, and the Southwark Foundry & Machine Co., Philadelphia, he designed and had built his first engine, a 7x8-inch automatic cut-off, at the shops of Charles F. Elmes, Chicago, Ill.

During his engagement with the Southwark Foundry & Machine Co., he made a deep study of the effects of inertia in the reciprocating parts of the steam engine, and to verify the results of his calculations he invented and had built at the Crosby Steam Gauge & Valve Manufacturing Co's works, Boston, an instrument which he applied to some Porter-Allen engines, and drew curves representing the inertia force at the various points of the stroke, which substantiated the correctness of his calculations. This he named the inertia instrument, and he wrote a series of articles on the subject which appeared in the "American Machinist" in 1884 and 1885.

Before the completion of his first engine, orders were obtained for two larger ones which were put into regular service in Chicago. The valves of these engines consisted of a main valve driven directly from an eccentric on the crankshaft and a balanced cut-off within it, driven by a shaft governor. The valves had flat faces, and the main valve was balanced by a pressure plate at its back, wholly surrounded by live steam and exhausting within or under the balance plate. After some experience with these valves, much difficulty being experienced in keeping such large pressure plates straight and free from leakage, he decided to change the system, dividing the large pressure plate into two smaller ones, placed one at each end of the steam chest admitting live steam into the intervening space and exhausting out the ends. It constituted in fact a piston valve of rectangular section provided with pressure plates having means for taking up the wear. This valve system proved successful, and trial steam tests showed remarkably good economy even after much use.

The governor consisted of two weight arms, one on each side of the main shaft, to which were attached weights and springs in the usual way and connected to the cut-off eccentric in a manner to lengthen or shorten the period of steam admission by revolving it around the shaft forward or back. Believing the effects of inertia could be utilized to advantage, an "inertia wheel" was mounted on the crankshaft beside the governor on a frictionless roller bearing, links so attaching it to the governor arms that the inertia effect of the wheel, when the engine speed accelerated, would have a tendency to lift the weight arms, shortening the period of steam admission, and when the speed was retarded the tendency was to depress the weight arms, giving the engine more steam.

After many trials with the inertia wheel attached and detached to the weight arms, it was decided to abandon the inertia wheel as the regulation did not appear to be benefited by its use This experiment was tried in 1886 or 1887.

Mr. Williams here became a firm believer in compound engines and unhesitatingly advocated them. The immediate result was an order from the Chicago Arc Light & Power Co., under the advice of its able engineer, J. A. Dyblie, for two horizontal, tandem compound engines of 500 horsepower each. The order to build them was given to William Tod & Co., Youngstown, Ohio, under Mr. Williams' personal supervision. These engines were entirely successful and were the pioneers of compounding in electrical service in this country.

The Williams' engine business was then taken up by Fairbanks, Morse & Co., Chicago, who built a shop for their manufacture at Beloit, Wis., Mr. Williams being employed as superintendent. A year or so afterwards he gave up this position and accepted an offer from the Lake Erie Engineering Works, of Buffalo, N. Y., and furnished them a new design of vertical compound and triple-expansion engines, the vertical design then coming into favor on account of the limited floor space required.

These engines were equipped with a new system of valves and governor. Four valves were used for each cylinder, the steam and exhaust being on opposite sides of the bore and driven separately. These valves were of the four-post construction, operating under pressure plates. They were originally self-adjusting because of the difficulty experienced in machining them perfectly. The self-adjusting feature was afterwards abandoned and the valves cast in one piece. The governor was of the one-armed gravity balanced type, which Mr. Williams used in all his future work.

A number of engines was turned out, the most noted one perhaps was the one installed at the Intramural power house at the World's Fair, Chicago, in 1893. This engine was a vertical compound, directly connected to an 800-kw. General Electric generator, one of the first ever built.

On July 4, expecting heavy traffic on the road, a 1500-kw. Corliss driven unit was put into service, assisted by a 500-hp. Greene engine belted unit; a 500-hp. McIntosh & Seymour, a 400-kw. tandem Corliss and the Williams 800-kw. vertical unit were to be kept in reserve. When the first heavy pull came on, an accident happened to the 1500-kw. generator, putting it out of service. The Greene and the McIntosh & Seymour were forced to lay down also. The attempt was then made to run the Williams and the tandem 400-kw. Corliss in parallel. The Corliss was soon brought to a standstill and had to be thrown out. To everyone's surprise the Williams vertical took the whole load with perfect ease, carried it the rest of the day, and ran the load exclusively for some weeks following.

After leaving the Lake Erie Company at the close of the World's Fair, Mr. Williams entered into a contract with William Tod & Co., he having charge of the New York office, where the sales were made and the drawings executed.

After having installed some fourteen engines under this arrangement, averaging approximately 800 hp. each. the business boom of 1900 came on and filled the William Tod works with work for the iron industries for long periods in the future, and the building of the Williams engines was discontinued. The association with the William Tod Co. was most pleasant from beginning to end.

Mr. Williams then redesigned his engines, using the old Williams flat valves in the high-pressure cylinders and four gridiron valves operated across the cylinders by a new system of levers on the low-pressure cylinders. The high-pressure valve being operated by the governor and the low-pressure steam and exhaust by separate eccentrics.

It was his belief that a single-valve governor control on the high-pressure cylinder and a fixed cut-off on the low-pressure was advisable on account of its simplicity, and that the economy in the use of steam would not be inferior to engines having independent cut-off on the high-pressure and governor control on the low-pressure cylinder as well as on the high-pressure, as at normal load the same distribution of pressures would be effected by either system, and there could be no rational difference in the economy, other things being equal.

Orders were taken for seven, two being of the single-cylinder type, and they were built in shops where they had no knowledge of the Williams engines. But they were not built satisfactorily and did not turn out well. This was disheartening, and the work was dropped until proper building facilities could be secured. A company was then organized at Quincy, Ill., with Mr. Williams as chief engineer, the business being managed by Thomas Hill and Edward C. Wells. A number of engines were put into successful service, all vertical.

The steam turbine then came on the market and ruined the vertical reciprocating engine sales. This was a great blow to the new Quincy enterprise, and he severed his connection and came East. Robert Wetherell & Co. then built a pair of his vertical compounds for North Beach, L. I., which were very satisfactory.

After completing the drawings for these engines he spent some time on drawings of a new steam turbine for E. H. Ludeman & Co., of New York. The first of these steam turbines is now under construction. His next work was in the capacity of a coworker with P. D. Johnston, of Cold Spring, N. Y., in the working out of a new oil-burning engine.

While at Cold Spring Mr. Williams conceived the idea of an economical high-speed vertical steam engine in sizes from 30 to 450 horsepower, and on leaving Cold Spring took up its development. This engine is of the inclosed self-oiling type, with two sets of reciprocating parts, the two high-pressure pistons being single-acting and the two low-pressure pistons double-acting.

JOHN B. ALLAN

John B. Allan, a prominent engineer and salesman identified with the power plant field, died on July 28 at his home in Oak Park, Ill. He was born in Davenport, Iowa, in 1860 and received his common and high-school education in that city. He completed a course in mechanical engineering at the Worcester Polytechnic Institute, graduating with the class of 1880. Mr. Allen entered the employment of Edward P. Allis & Co. in 1881 and served in various capacities until he was made manager of the Chicago office, which was the first branch office started by the company. Mr. Allan was prominently identified with the early development of the street and elevated railways of Chicago. He sold most of the power-house equipment at the time the systems were changed from the horse cars to cable cars and later to electric lines. At the organization of the Allis-Chalmers Co., he was made vice-president and general manager, which position he held until 1904. At that time he resigned and was made general Western sales manager of the Westinghouse Machine Co., with headquarters in Chicago. In 1910 failing health overtook Mr. Allan and he was compelled to give up active business. Probably no man in a similar capacity was better known to the profession.

JOHN B. ALLAN

Mr. Allan had been in failing health for some time and the immediate cause of his death was tumor on the brain. Thousands of his many friends throughout the country will mourn his untimely death. He leaves besides his widow, three children, James R., Ruth R. and Margaret B., and a sister, Mrs. John Graham of San Diego, Calif. The funeral services were held at the residence on Friday morning and the burial was at Grand Rapids.

NEW EQUIPMENT

ATLANTIC COAST STATES

The City Commission, Bordentown, N. J., contemplates installing a municipal electric-light plant at an estimated cost of $40,000.

Press reports state that the Singer Mfg. Co., Elizabeth. N. J., will build a new power station at its plant at Elizabethport.

The Town Council, Gettysburg, Penn., plans to construct a municipal electric-light plant. An engineer will be engaged to prepare plans and estimates for the plant.

SOUTHERN STATES

The Board of Aldermen, Maben, Miss., has granted a franchise to F. H. Mudd, for the establishment of an electric-light plant at Maben.

Bids will soon be received by the city of Nashville, Tenn., for a motor-driven pump. The bids recently received were rejected on account of being too high.

The Cave City Ice Co., Cave City, Ky., contemplates installing an electric-light plant in connection with its present equipment.

Bids will be received by S. D. Jones, Business Mgr., of the Board of Education, Louisville, Ky., until Aug. 19, for the installation of heating and ventilating equipment in the Flat Lick School.

POWER

Vol. 40 NEW YORK, AUGUST 25, 1914 No. 8

Fools

By R. T. Strohm

Gone is the epoch of dark superstitiousness;
  Wisdom and reason have put it to flight.
Almost forgot are its folly and viciousness,
  Faded and dim as a dream of the night.
Far have we journeyed and fast are we traveling,
  Leaving Old Ignorance bogged in his tracks,
Yet there is room for complaining and caviling;
  Still there is work for the fool-killer's ax.

Though we are wondrously wise in these latter days,
  Cynics will criticize, snicker and smirk,
Reading of boilers, with fires banked Saturdays,
  Bursting on Mondays when put to their work.
Maybe it chanced through a fireman's blundering;
  Maybe inspection was lacking or lax;
Yet we are prone to a natural wondering
  Whether there's work for the fool-killer's ax.

Spite of all efforts in lines educational,
  Spent upon every condition and rank,
Some one, unconsciously growing sensational,
  Opens the blow-off valve wide with a yank.
Elsewise some idiot, while his superior
  Seeks in a boiler for pitting and cracks,
Opens a steam valve and fills the interior,
  Yes, there is work for the fool-killer's ax.

Still we are cursed by some absolute dunderpate
  Loading the safety-valve lever with junk,
Letting the scale collect, burning the under plate,
  Courting disaster by working while drunk.
Round up these rogues who are acting so fearfully;
  Bind them securely, their hands at their backs;
Send for the headsman and bid him come cheerfully,
  Here is good work for the fool-killer's ax.

Power Plant at Hillsboro, Ill.

By Thomas Wilson

SYNOPSIS—A 1750-kw. condensing plant furnishing current for street and residence lighting, power and street-railway service, exhaust steam for heating and making ice, besides pumping the city water.

⁂

At the town of Hillsboro, Ill., which has a population of 7500, are located the offices and the main plant of the Southern Illinois Light & Power Co. The plant is interesting, as it supplies seven different services in the home town and current to a number of surrounding towns. There are 90 miles of transmission lines connecting the various substations, and where heating is also required, prime movers are installed to operate in parallel with the main station. Three-phase, 60-cycle current is generated, and for transmission to distant substations is stepped up to 16,500 and 33,000 volts. In each of these towns the arc and residence lighting and power demands are supplied. The street-railway load consists of the Hillsboro and Taylor Spring lines, and besides current is fed into the McKinley system. Exhaust steam at 5-lb. pressure heats the business district of Hillsboro, and from 5,000,000 to 10,000,000 gal. per month of city water is pumped at the station. It may be of interest to learn that a correspondence school student, Jesse L. Best, while completing his studies, was directly responsible for the layout of the station to J. J. Frey, president and general manager of the company. He had charge of the installation of the machinery and is now chief engineer. As soon as time permitted, he worked up an excellent system of records, so that it was possible to divide the total costs between the various services of the plant.

Briefly, the equipment consists of 1144 hp. in four water-tube boilers, although in the very near future two 400-hp. boilers will be added. In the engine room there is capacity to generate 1750 kw., which reduces to 1.53 kw. per hp. of boiler rating. With the new boilers installed, the ratio will drop to 0.9. For the generating capacity of the station, the boiler power is high, but of course steam is required for a 25-ton absorption refrigerating plant. During the heating season live steam is used occasionally, and during the colder months steam-driven pumps supply the city water. There is also a probability of installing additional generators as the load is constantly increasing.

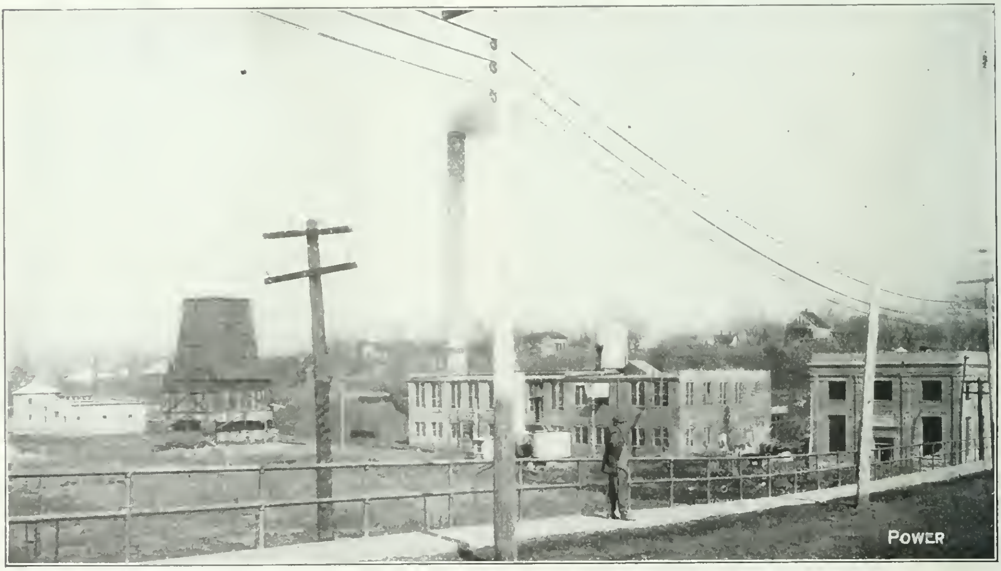


Fig. 1. Hillsboro Station of the Southern Illinois Light & Power Co.

The building, Fig. 1, is a two-story brick structure, 76x140 ft., equipped with fireproof doors. The boiler and engine rooms are located at the stack end of the building, the boiler-room floor being on a level with the basement under the engine room. In the latter are located the condensers and some of the pumps, while at the opposite end of the building is the ice-making plant. At the right is a new transformer house and at the left is a large cooling tower, as in this territory the supply of water is limited.

Boiler Room

As intimated previously, there are four 286-hp. water-tube boilers, with provision for the early installation of two more rated at 400 hp. each. The operating pressure is 165-lb. gage. Each boiler is equipped with a shaking grate, 7 ft. 3 in. long and 8 ft. 6 in. wide, set 3 in. lower at the rear end. Provision was also made for stoker settings, and at the present writing, work is under way to install chain grates. In each boiler there are 2858 sq.ft. of heating surface and its ratio to the total surface in the grate is 46.4 to 1. The effective surface in the grate would, of course, be less, so that the true ratio would probably reach the conventional 50 to 1.

At the stack the breeching measures 5 ft. 8 in. by 10 ft. 6 in. and gradually tapers toward the last boiler. The stack is of reinforced concrete, offset type, 8 ft. in diameter and 150 ft. high. Consequently, the breeching area is 59.5 sq.ft. to 50.26 sq.ft. in the stack. For every square foot of breeching area there are 4.1 sq.ft. of connected grate, and for 1 sq.ft. of stack area, 1.9 sq.ft. of grate. Per horsepower of boiler rating the stack has a sectional area of 0.044 sq.ft., or 6⅓ sq.in. These figures run close to average practice. Illinois screenings, 1½-in. Hillsboro, is the fuel burned. The draft at the base of the stack runs close to 0.7 in., and over the fire it averages from 0.2 to 0.15 in., depending on the thickness of the fuel bed and the condition of the fires.

The boilers are provided with feed-water regulators, and a water meter measures the supply. Three-tier permanent platforms give access for blowing and cleaning the tubes. The blowing is done by steam every 24 hr., while the hard deposit in the tubes is removed by a turbine cleaner driven by air compressed to 60 lb. pressure by a locomotive type compound air compressor mounted on the engine-room wall. From each boiler, a 7-in. pipe leads to a 10-in. header containing an angle valve and an automatic stop and check valve.

Water for feed purposes is drawn from a creek ¼ mile distant through a twin filter and is delivered to a 1000-hp. open heater which receives the exhaust from the pumps. Duplicate feed pumps of the duplex outside center-packed type, 10 and 5½ by 10 in., are installed and are controlled by pump governors.

The coal at present is dumped directly from railway cars into a 20x88-ft., 600-ton bin at the side of the boiler room. Through doors at the bottom of the bin it is delivered onto the boiler room floor and hand-fired into the furnaces. The plant is on the side of a hill, so that the elevation of the ground makes this arrangement possible. When the stokers are installed, automatic delivery to their hoppers is contemplated, but the method is still open to decision.

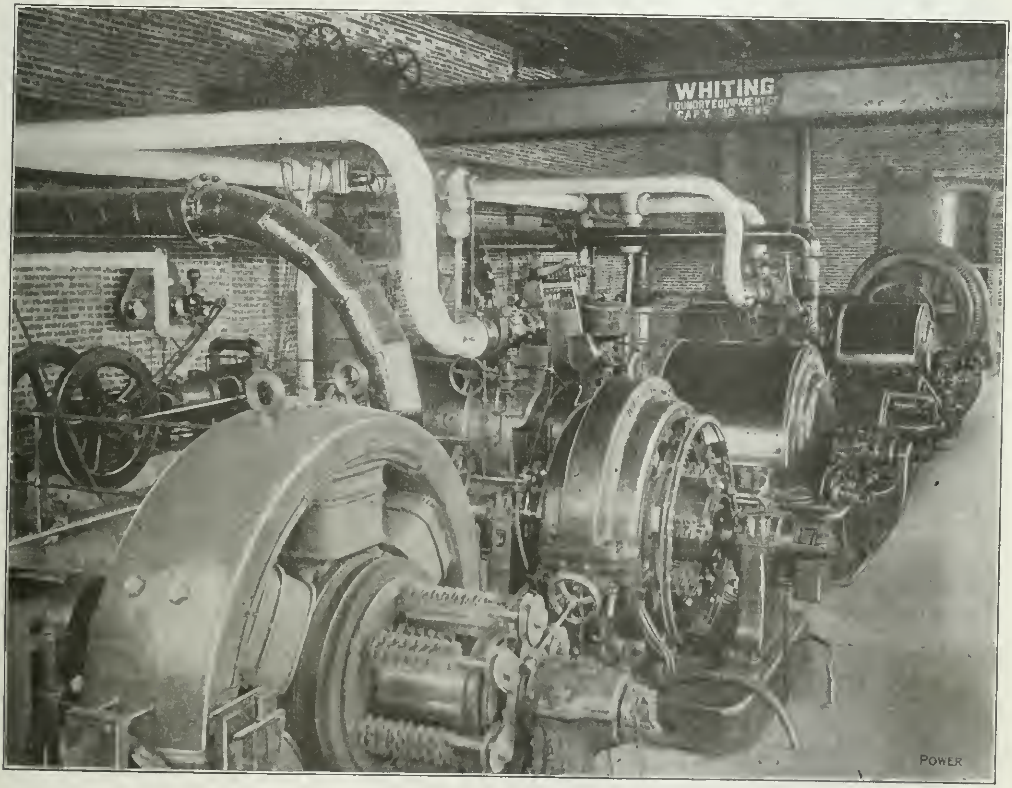


Fig. 2. The Turbine Room of the Plant

Engine Room

In this department, shown in Fig. 2, the main generating units are two 750-kw. two-stage impulse turbines driving three-phase, 60-cycle generators at a speed of 3600 r.p.m. There is also a 250-kw. alternator driven at

200 r.p.m. by a simple noncondensing 20x20-in. engine. This unit is run mostly during the heating season to supply exhaust steam at 5-lb. pressure. The electrical load is varied to suit the demand for steam, and the balance, which is the greater part of the output, is carried by one of the turbo-generators, operated condensing at an average vacuum of 28½ in. The two machines operate in parallel. The turbines are of the bleeder type; that is, provision has been made to draw off steam between the stages at 5-lb. pressure for the heating. The engine and pumps, however, have supplied enough exhaust steam so that there has been no occasion to call on the turbines. The condensers are of the surface type, each containing 2600 sq.ft. of surface, or 3.47 sq.ft. per kw. of turbine rating. At full load and 28½ in. of vacuum, the turbines will develop a kilowatt-hour on 19 lb. of dry saturated steam, so that at full load there will be an hourly discharge to the condenser of

$$750 \times 19 \times 0.77 = 10,972 \ lb.$$

of steam. Of this, each square foot of surface must condense 4.22 lb. The turbine exhaust to the condenser is 30 in. in diameter, and to pass 10,972 lb. of steam per hour, equivalent to 182.87 lb. per min., or at a pressure of 0.7 lb. abs. 85.821 cu.ft., would necessitate a velocity of nearly 17,500 ft. per min. The live steam supply pipe to each turbine has a diameter of 4½ in. and an area of 15.947 sq.in., which amounts to 0.0212 sq.in. per kw. of turbine rating as compared to 0.94 sq.in. for the exhaust. Passing 182.87 lb. per min. of dry saturated steam at 165 lb. gage through this pipe calls for a velocity of 4191, or practically 5000 ft. per min.

For the condensers the circulating water and the condensation are handled by centrifugal pumps. Each circulating pump (there is one for each condenser) has a 10-in. suction and an 8-in. discharge. The capacity being 1800 gal. per min. permits the supply of 82 lb. of water to 1 lb. of steam. The supply is taken from the creek previously mentioned, and from the condensers is passed to a natural draft cooling tower 44x55 ft. in plan and 76 ft. high. It is guaranteed to cool 2800 gal. of water per minute from 106½ to 85 deg. when the outside temperature is 75 deg. and the humidity 70 per cent.

Condensate from the condensers is discharged by 2-in. two-stage turbine-driven pumps to a 10,000-gal. distilled water tank. A small part of this water is drawn off for ice making and the balance is boiler feed. The dry-vacuum pumps are of the reciprocating crank and flywheel type dimensioned 10x16x10 in.

All steam-driven auxiliaries and the engine exhaust into a 12-in. main at a level lower than the engine-room floor, and for an emergency atmospheric exhaust the turbines are also connected to this main. At one end is the heater and the atmospheric exhaust, and at the other end the main, reducing to 10 in., continues to the business district, where it supplies exhaust steam at 5 lb. pressure to 25,276 sq.ft. of radiation. The condensation from this surface is trapped to the sewer and not returned to the plant, as in some cases.

MONTHLY REPORT OF MAIN GENERATING STATION AT HILLSBORO

	January, 1914	May, 1914
Coal consumed, lb.	2,729,900	2,380,900
Water evaporated, approx., lb.	15,000,000	13,518,000
Water evaporated per lb. coal, lb.	6.5	5.68
Kw.-hr. generated	228,630	291,288
Kw.-hr. delivered	210,840	261,961
Kw.-hr. used in station	16,590	28,144
Kw.-hr. used in ice plant	1,200	1,183
Ice pulled, lb.	72,450	738,900
Coal for ice, lb.	30,000	170,000
Steam for ice, lb.	180,000	769,000
Coal for steam heat, lb.	200,000	None
Steam for steam heat, lb.	4,000,000	None
Coal for pumping, lb.	158,000	180,000
Coal for electric service, lb.	1,915,800	2,025,900
Coal per kw.-hr.	8.37	6.95
Ice per ton of coal, tons	2.4	4.34
City water pumped, gal.	7.185,225	5,060.375
Power used	None	None
Coal for storage, lb.	410,100	None
Gas-plant coal, lb.	None	5,000
Coal sold, lb.	16,000	None

COSTS OF PRODUCTION, ELECTRIC

Station wages	$472.62
Coal:	
Cost	718.46
Freight and drayage	84.50
Handling	142.10
Water	......
Lubricants, waste	20.75
Supplies and expense	13.90
Maintenance of boilers	44.27
Maintenance of engines	24.33
Maintenance of electric apparatus	1.30
Maintenance of miscellaneous station equipment	34.74
Maintenance of buildings	......
Power in station	215.67
Total costs	$1772.64
Cost per kw.-hr.	0.0077

COSTS IN OTHER DEPARTMENTS

	Steam Heat	Ice Dept.	City Pumping
Wages	$43.00	$13.90	$36.00
Coal:			
Cost	75.00	11.25	59.25
Freight and dray.	8.00	1.35	6.50
Handling	12.00	1.80	9.48
Power	10.80	......	......
Supplies and expense	......	128.22	......
Maintenance miscellaneous station equipment	28.04	9.20	5.00
Total costs	$176.84	$165.72	$116.23
Cost per unit	4.4c. per M. lb.	$4.57 per ton	$0.016 per M. gal.

To supply 600-volt direct current for street-railway service there are two rotary converters, one 200 kw. and the other 300 kw. There are two 35-kw. exciters, one motor-driven and the other driven by a steam turbine. The latter is seldom used. The switchboard, Fig. 3, is of standard design, equipped with hand-operated oil switches, the latest instruments, a synchroscope and a Tirrell voltage regulator.

For pumping the city water, two duplex steam pumps, 14 and 8½ by 10 in., are installed. These pumps work against a head of 175 to 185 ft., and are used mostly in the winter months when exhaust steam is needed for heat-

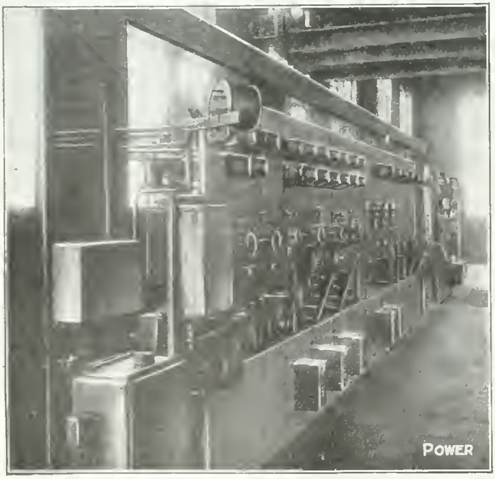


FIG. 3. VIEW OF THE SWITCHBOARD

ing. At other times the water is supplied by a 5-in. two-stage turbine pump driven by a three-phase 50-hp. motor. A 6-in. turbine meter measures the supply to the city.

As previously stated, the ice-making plant is of the absorption type, the capacity being 25 tons. The part of the equipment located in the basement is shown in Fig. 4. Exhaust steam from the brine, distilled-water and aqua pumps is usually sufficient to carry the load, which is light in winter due to small storage, and up to full capacity in the summer months. The ice is made in 300-lb. cans, of which there are 357, and the time of freezing is 52 hr. The condenser is of the double-pipe type having 1½ and 2½-in. pipe. To conserve the water supply to the condenser, it is passed through a forced-draft tower having a capacity of 300 gal. per min. The tower is 10 ft. in diameter and 34 ft. high. An 8-ft. disk fan driven by a 15-hp. belted motor creates the draft.

Costs of Production

From the preceding, a fair idea will be obtained of the plant equipment, and the monthly report shows what this equipment has been doing. The operating data for the months of January and May of 1914 are given, but

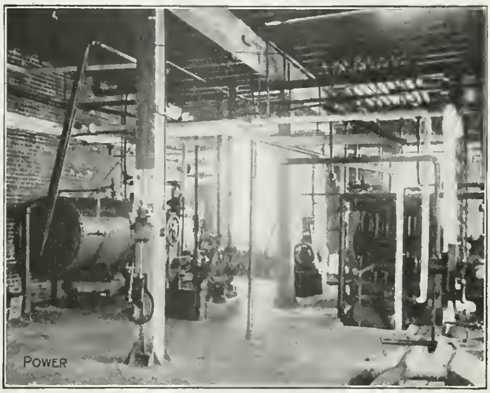


Fig. 4. Part of the Refrigerating System

PRINCIPAL EQUIPMENT OF HILLSBORO POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling-Class Q	286 hp.	Generate steam	165 lb. gage, natural draft, band fired	Babcock & Wilcox Co.
4	Grates	"Treadkill" shaking grate	7 ft. 3 in. x 8 ft. 6 in.	Boiler furnace	Draft 0.7 in. base of stack, 0.35 in. over fire	H. M. Treadwell Co.
1	Chimney	Concrete, offset type	150 ft. high, 8 ft. dia.	Natural draft for boilers		Weber Chimney Co.
4	Feed water regulators	Turbine		Water level in boilers		Liberty Mfg. Co.
1	Strainer	Elliott	3-in. pipe con.	Strain water to plant		Elliott Co.
2	Pumps	Duplex, outside packed	10x5x10-in.	Water to boilers	Steam 165 lb. gage, head 400 ft.	Henry R. Worthington
2	Pump governors	Elliott		Regulate feed pumps		Elliott Co.
1	Feed-water beater	Open	1000 hp.	Heat feed-water	Exhaust steam	Harrison Safety Boiler Works
1	Pump	Direct-acting	7x6x10-in.	Distilled water to ice cans	Steam 165 lb. gage	National Foundry & Machine Co.
2	Pumps	Duplex	14x8½x10-in.	Pump city water	Steam 165 lb. gage, head 185 ft.	Henry R. Worthington
1	Pump	Turbine two-stage	5-in.	Pump city water	Motor-driven, capacity 600 gal. per min.	Alberger Pump & Condenser Co.
1	Motor	Alternating-current	50 hp.	Drive city-water pump	220 volt, three-phase, 1730 r.p.m.	Wagner Electric Mfg. Co.
2	Turbines	Impulse two-stage	750 kw.	Main unit	Saturated steam 165 lb. gage, 3600 r.p.m.	General Electric Co.
2	Generators	Alternating current	750 kw.	Main unit	Three-phase, 60-cycle, 2300 volt, 3600 r.p.m.	General Electric Co.
2	Condensers	Surface	2600 sq.ft.	For turbine units	28½ in. vac., 1800 gal. of water per min.	Henry R. Worthington
2	Pumps	Volute	10-in. suc., 8-in. dis	Condenser circulating water	600 to 1165 r.p.m.	Henry R. Worthington
2	Motors	Alternating-current	15 hp.	Drive circulating pumps	600 to 1165 r.p.m.	Wagner Electric Mfg. Co.
2	Pumps	Turbine	2-in., 2-stage	Condensate	Turbine driven, 1550 r.p.m.	Henry R. Worthington
2	Turbines	Impulse single-stage	5 hp.	Drive condensate pumps	Steam 165 lb. gage, 1550 r.p.m.	Terry Steam Turbine Co.
2	Pumps	Dry vacuum	10×16x10-in.	Air from condensers	Steam 165 lb. gage	Henry R. Worthington
1	Engine	Simple noncondensing	20x20-in.	Main unit	Steam 165 lb. gage, 200 r.p.m.	Chuse Engine & Mfg. Co.
1	Generator	Alternating-current	250 kw	Main unit	Three-phase, 60-cycle, 2300 volt, 200 r.p.m.	Western Electric Co.
1	Rotary converter		200 kw.	Direct current for St. Ry.	2300-volt a.c. to 600 volt d.c.	Westinghouse Electric & Mfg. Co.
1	Rotary converter		300 kw.	Direct current for St. Ry.	2300-volt a.c. to 600 volt d.c.	General Electric Co.
1	Exciter		35 kw.	Excitation for main units	Motor-driven, 1200 r.p.m.	General Electric Co.
1	Exciter		35 kw.	Excitation for main units	Turbine-driven, 3600 r.p.m.	General Electric Co.
1	Crane	Traveling	10-ton	In engine room	Motor driven.	Whiting Foundry Equipment Co
1	Cooling tower	Natural draft	44x55x76 ft.	Cool condensing water		Wheeler Condenser & Engineering Co.
1	Refrigerating system	Absorption	25 ton	Making ice	Exhaust steam, brine, time of freezing 52 hr.	Carbondale Machine Co. Henry Vogt Machine Co.
1	Pump	Volute	1-in.	Water for ammonia condenser	Turbine driven, 2500 r.p.m.	Jeanesville Iron Works Co.
1	Turbine	Single-stage impulse	10 hp	Drive circulating pump	Steam 165 lb. gage, 2500 r.p.m.	Terry Steam Turbine Co.
1	Pump	Centrifugal	3-in.	Circulate brine	Motor driven, 180 gal. per min., 1750 r.p.m.	Jeanesville Iron Works Co.
1	Motor	Single-phase	5 hp.	Drive brine pump	220-volt, 1750 r.p.m.	Wagner Electric Mfg. Co.
1	Pump	Centrifugal	3-in.	Circulate brine	Motor driven, 200 gal. per min., 1165 r.p.m.	Jeanesville Iron Works Co.
1	Motor	Single-phase	2 hp.	Drive brine pump	220 volt, 1165 r.p.m.	Wagner Electric Mfg. Co.
1	Pump	Simplex	10x5x12-in	Aqua pump	Steam 165 lb. gage	Carbondale Machine Co.
1	Cooling tower	Forced draft	10x34-ft., 300 gal. per min.	Cool water from ammonia condenser		Ruemmeli-Dawley Mfg. Co.
1	Fan	Disk type	8 ft. dia.	Draft for cooling tower	Belted to motor, 250 r.p.m	Fairbanks Morse & Co.
1	Motor	Three-phase	15 hp.	Drive fan	220-volt, 1165 r.p.m.	Fairbanks Morse & Co.
1	Air compressor	Compound locomotive type	Steam 10½x16¾x12 Air 9½x11½x12	Compressed air for boiler tube cleaner, etc.	Steam 165 lb. gage, air 60 lb.	Westinghouse Air Brake Co.

the costs per unit for the various services are available for only the first month in the year. Glancing over the figures it will be seen that the records are not as good as might be expected from an uptodate plant, but an analysis will show the reason. The coal, which is Illinois screenings averaging about 10,000 B.t.u., was hand fired, and as the boilers were operated under fluctuating loads, the evaporation ranged from 5.68 to 6.5 lb. of water per pound of coal. This same fluctuating load, caused largely by the street railway demand and the use of saturated steam in the turbines, resulted in a comparatively high steam rate and the consumption of 6.95 to 8.37 lb. of coal per kilowatt-hour. The cost per unit. 0.77c., which includes operating charges and maintenance, is not excessive, although the coal costs only 82c. per ton delivered. With the load increasing as it should in the near future and the change from hand to mechanical firing, better results are expected.

The cost of 4.4c. per 1000 lb. of steam is unusually low, but only that steam coming from the engine was charged against the heating, the exhaust steam from the city water pumps and other sources being chargeable to other departments. On the other hand, a charge of $4.57 per ton of ice is excessive, but in the month of January only 36 tons were made, a daily output of but little over one ton per day of 24 hr. When running up to capacity in the hot summer months, the operating and maintenance cost ranges around 85c. per ton.

Due to the complexity of the service, it was a difficult matter to separate the costs. It would appear, however, that the engineer had the matter well in hand, for the records are complete and show familiarity with the details. The layout of a plant, its installation, the efficient operation of the equipment and finally, accurate records from which to obtain the cost of production, is a thorough test for any engineer. In the present case it is all the more creditable, as the engineer, while under his present employer in a smaller plant, fitted himself for the work by spending his evening hours in study. Mr. Best is to be congratulated on his success and the management in turn for giving him the chance to show his "mettle."

※

Applications and Types of Boosters--II

By John A. Randolph

SYNOPSIS—The use of the constant-current booster where both fluctuating and steady loads are supplied from the same busbars; also descriptions of the separately excited type and those used on three-wire systems.

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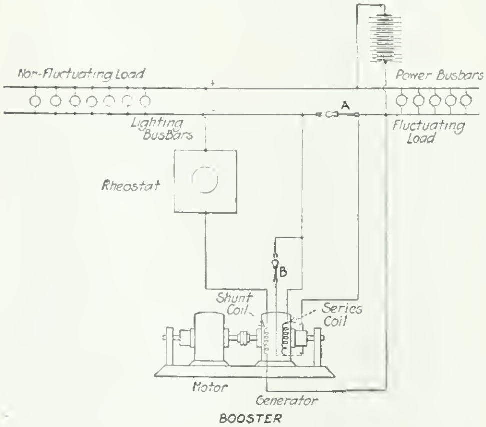

Fig. 1.

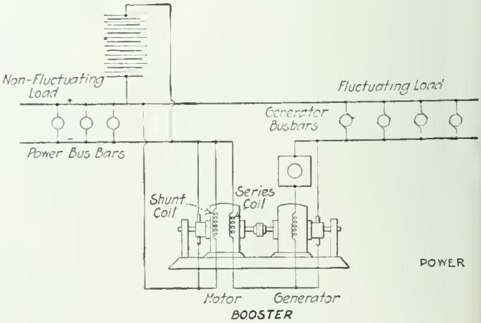

Fig. 2.

Types of Constant-Current Boosters

In many installations, especially in private plants, it is necessary to supply a fluctuating or power load and a nonfluctuating or lighting load from the same busbars. To do this without disturbing the lights, a so-called constant-current booster and battery are connected into the power circuit, one form of which is shown in Fig. 1. There are a series and a shunt field winding on the booster, and all of the power load must pass through the series coil. The shunt coil is so wound that it tends to assist the busbar voltage while the series winding opposes the shunt. Ordinarily the shunt field predominates, causing the voltage on the power busbars to be slightly higher than that of the lighting busbars. When a heavy power load is thrown on the system, the additional current in the series coil at once lowers the booster pressure and consequently that of the power busbars, causing the motors to start more slowly. This action relieves the station generators of a sudden heavy demand for current and thus enables them to maintain their normal voltage on the lighting load. When the voltage of the power mains drops sufficiently, the battery floating on the line will at once begin to discharge and take part of the load, thereby preventing any disturbance in the operation of the system. As the motor load again becomes normal, the current in the booster series winding becomes less and the booster voltage rises until the pressure on the power busbars again becomes normal. The battery will now stop discharging. A further falling off of the power load will cause the power busbar voltage to rise still higher, with the result that a charging current begins to flow into the battery. A system of this kind, when properly adjusted, will maintain practically constant current on the lighting busbars.

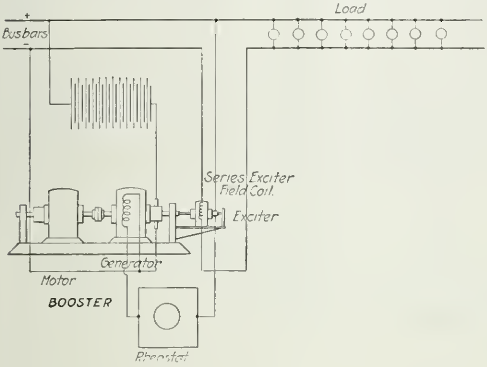

FIG. 3.

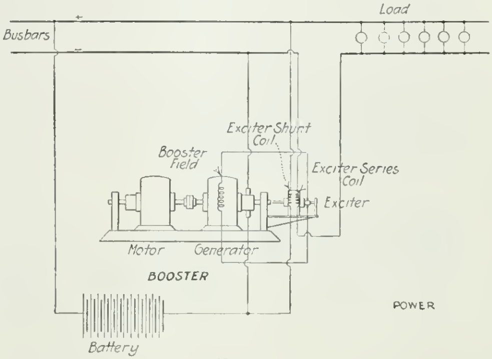

FIG. 4.

SEPARATELY EXCITED BOOSTERS

If it is desired to connect the battery to the lighting load, this can be accomplished by disconnecting the booster and closing the switch *A*. Switch *B* is for the purpose of cutting out the series coil in case it becomes necessary to apply a higher voltage to the power busbars than could be done with the coil in circuit, for battery charging or other reasons.

The connections for another type of constant-current booster are illustrated in Fig. 2. In this machine the voltage on the power busbars is raised and lowered to meet the fluctuations of the load, as in the case shown in Fig. 1, but it is accomplished in a different manner, the booster voltage being varied by changing the speed. The booster motor is compound wound and the power load must pass through the series coil, which is wound to assist the shunt winding. Therefore, as the load rises, the magnetizing flux of the motor will increase proportionately and result in decreased speed of the motor. This will cause the voltage of the booster generator to fall, thereby lowering the voltage on the power mains and enabling the battery to discharge. As the load falls off, the speed of the motor increases and brings the power voltage back to normal.

SEPARATELY EXCITED BOOSTER

In this type, the field excitation is controlled by a small exciter mounted either on the end of the booster shaft or on an independent base. A diagram of connections for one form is shown in Fig. 3. The booster generator has but one field coil, and this is in series with a regulating rheostat and the exciter armature, across the busbars. The exciter field coil is in series with the load and is so wound that the electromotive force which it induces in the exciter armature opposes that of the station busbars. The exciter voltage will vary with the magnetic flux produced by the field coil, or, in other words, with the current passing through the coil. When the external load becomes so great that the exciter voltage is higher than the busbar voltage, the current sent by the exciter through the booster field will be of such a direction as to cause the booster to assist the battery to discharge. On the other hand, when the external load becomes so light that the exciter voltage is less than that of the busbars, the direction of the current flowing through the booster field winding will be such as to cause the booster to assist the station busbars in sending a charging current through the battery.

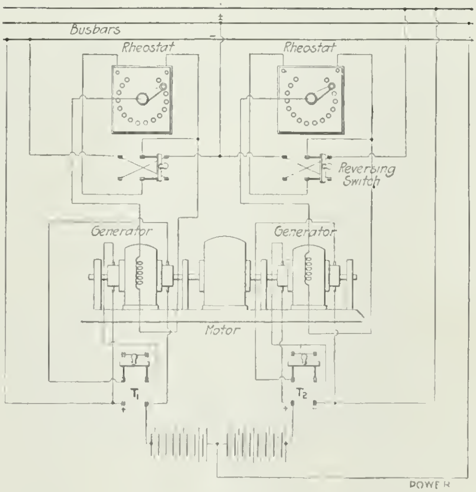

FIG. 5. BOOSTER FOR THREE-WIRE SYSTEM

Another type of separately excited booster is shown in Fig. 4. The exciter in this case carries two sets of field coils, one in series with the load and the other a shunt winding. The latter is wound to cause the exciter to induce a voltage in the booster which assists that of the busbars. The series winding opposes the shunt. The operation of a booster thus excited is similar to that of the differential machine, shown in Fig. 1, Part I (page 237, Aug. 18 issue). A heavy load through the exciter series coil tends to cause the latter to overpower the shunt coil, with the result that the booster is made to assist the battery to discharge. As the load falls off, the exciter shunt winding again comes into action and sends a current through the booster field of a direction such as to cause the booster to assist the busbar pressure in sending a charging current through the battery.

Boosters for Three-Wire Systems

The types of boosters thus far considered have had but one generator. Sometimes, however, especially on three-wire systems, it is found more economical to use a booster composed of two generators driven by the same motor. Furthermore, where heavy currents are involved and a wide range of voltage is also desired, it has been found advisable to use on the booster-generators, armatures with two independent windings and two commutators. With this arrangement, the two windings of each armature can be operated either in parallel or in series, as may be desired. When in parallel the voltage will be half the value secured by series operation, but the current capacity will be doubled. Moreover, the use of double windings and two commutators renders it possible to carry heavy loads without unduly increasing the commutating parts of the machine. In Fig. 5 is shown the diagram of connections for such a machine as used on a three-wire system. There is but one field winding on each generator, and this is shunted between the neutral and one of the outside legs of the system. It will be observed that, in addition to a lead from an outside leg, the neutral is connected to each field rheostat. By this arrangement, the field coils, at the throwing over of the reversing switches, can discharge their back electromotive force of self-induction through a portion of the rheostate resistance, thus preventing a heavy arcing at the reversing switches.

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Hand-Fired Furnaces for Water-Tube Boilers--I*

By Osborn Monnett†

SYNOPSIS—Typical designs of furnace, with dimensions, for burning bituminous coal smokelessly under horizontal water-tube boilers.

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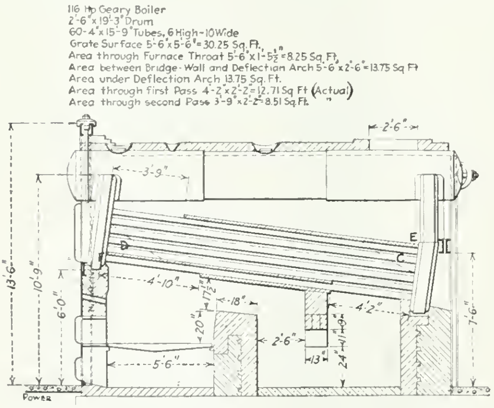
116 Hp Geary Boiler
2'-6" x 19'-3" Drum
60-4" x 15'-9" Tubes, 6 High-10 Wide
Grate Surface 5'-6" x 5'-6" = 30.25 Sq. Ft.
Area through Furnace Throat 5'-6" x 1'-5½" = 8.25 Sq. Ft.
Area between Bridge-Wall and Deflection Arch 5'-6" x 2'-6" = 13.75 Sq Ft
Area under Deflection Arch 13.75 Sq. Ft.
Area through first Pass 4'-2" x 2'-2" = 12.71 Sq Ft (Actual)
Area through second Pass 3'-9" x 2'-2" = 8.51 Sq. Ft. "

Fig. 1. Typical Hand-Fired Furnace for Horizontally Baffled Water-Tube Boilers

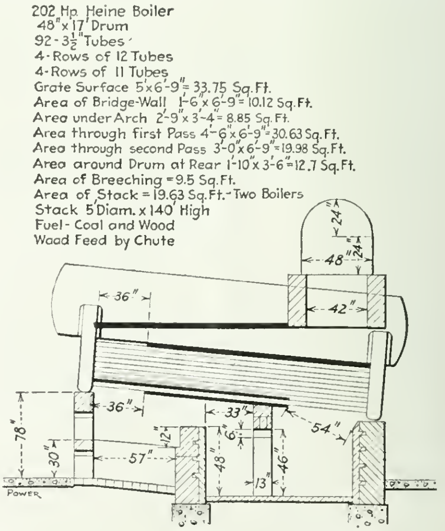
202 Hp. Heine Boiler
48" x 17' Drum
92-3½" Tubes
4-Rows of 12 Tubes
4-Rows of 11 Tubes
Grate Surface 5' x 6'-9" = 33.75 Sq. Ft.
Area of Bridge-Wall 1'-6" x 6'-9" = 10.12 Sq. Ft.
Area under Arch 2'-9" x 3'-4" = 8.85 Sq. Ft.
Area through first Pass 4'-6" x 6'-9" = 30.63 Sq. Ft.
Area through second Pass 3'-0" x 6'-9" = 19.98 Sq. Ft.
Area around Drum at Rear 1'-10" x 3'-6" = 12.7 Sq. Ft.
Area of Breeching = 9.5 Sq. Ft.
Area of Stack = 19.63 Sq. Ft.-Two Boilers
Stack 5' Diam. x 140' High
Fuel-Coal and Wood
Wood Feed by Chute

Fig. 2. Heine Boiler with Chute-Feed, Wood-Burning Furnace

In applying the principles of the hand-fired furnace as outlined in previous articles to water-tube boilers, an effort has been made to approximate the same conditions and provide the same essential details that have been worked out for horizontal return-tubular boilers. Fig. 1 shows a typical setting for a hand-fired water-tube boiler which has proved satisfactory for bituminous coal. The boiler is a 116-hp. Geary and has one horizontal pass, but this type of setting can be easily adapted to any horizontal water-tube boiler. The essential feature of the furnace is, first, provision for heat absorption direct from the fire by the bottom row of tubes, thus producing the "cooling" effect so desirable with high-volatile coals. This is obtained by using T-tile for a distance of 4 ft. 10 in. from the front header. From this point the regular box tile covers the tubes and forms another element essential to the success of hand-fired furnaces, namely, a high-temperature zone into which the gases and air must pass. Back of the bridge-wall a deflection arch is provided of such height as to allow an area underneath of 50 per cent. of the grate surface. In settings of this type the controlling height factor, which is usually measured from the floor line to the bottom of the front header, is governed by the ability to get the necessary area of 25 per cent. of the grate surface over the bridge-wall, 40 per cent. between the bridge-wall and deflection arch and 50 per cent. under the deflection arch.

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†Smoke inspector, City of Chicago.

With wide boilers containing three or four firing doors, the deflection arch is built in two or three spans with 13½-in. piers to decrease the strain on the side walls and obtain more permanent construction. If with these wide settings there is an area over the bridge-wall greater than the required 25 per cent. of the grate surface, 9-in. piers can be placed on the bridge-wall opposite the spans in the deflection arch to help break up the gases as they pass through the furnace.

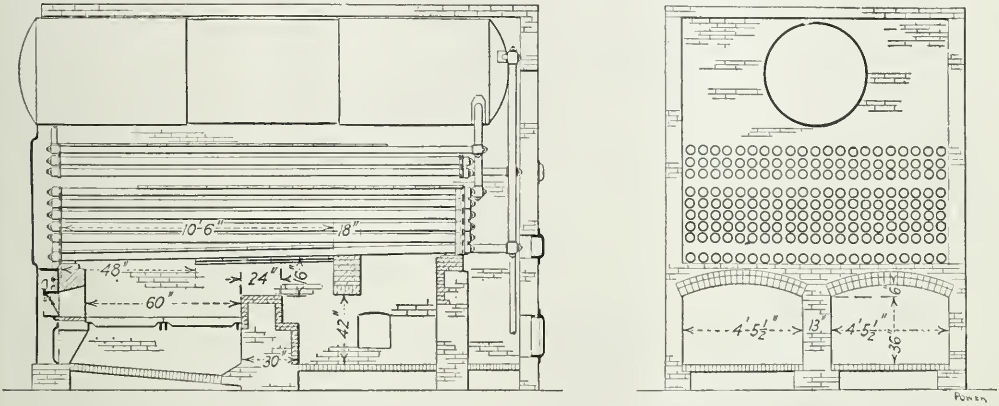

Fig. 3. Parker Boiler with Hand-Fired Furnaces

In this type of furnace the air-admission panel doors and siphon steam jets should be used as with the horizontal return-tubular boiler setting. When using the Heine baffle shown, it sometimes happens that there are zones of inert gas, as indicated at *C* and *D*, Fig. 1. In this case the efficiency of the setting can be increased by opening up the baffle at *E* and *F* about 1 in. on every other tile. A bypass for the gases at either point makes the heating surface more effective. For all types of horizontal baffles this point is worth investigating, as in many instances the openings have improved results.

Fig. 2 shows another successful setting of this type. The fuel was a mixture of wood refuse and coal. It was necessary, therefore, to cool off the furnace as much as possible to prevent puffs of dense smoke while using the coal and at the same time have the furnace hot enough to handle the dry shavings fed through a chute. A compromise was effected with satisfactory results by removing 3 ft. of the box tile, which is a little more than half the length of the grates, and exposing the lower tubes for this distance from the header.

Fig. 3 shows how the same idea was applied to a Parker boiler, where the tubes are bared for a distance of 4 ft. from the front header by using T-tile. Box tile were used for the remainder of the distance, and a two-span deflection arch was provided.

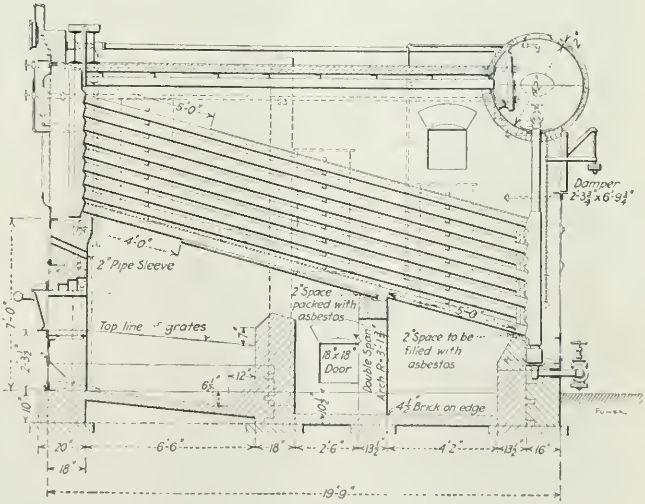

Fig. 4. Hand-Fired Furnaces for B. & W. Cross-Drum Boilers

Fig. 4 shows a typical hand-fired furnace applied to a B. & W. cross-drum boiler. This type of boiler has a tube pitch greater than any other of the standard horizontal water-tube boilers, so that a higher setting is necessary to give the proper area over the bridge-wall and sufficient space in the combustion chamber. The other characteristics of the setting are similar to those preceding.

Combination fire- and water-tube boilers are sometimes encountered, and where the tube length is approximately

18 ft., there is no trouble in applying the standard furnace. Such a boiler is shown in Fig. 5, which presents sectional views of a Kroeschell combination fire- and

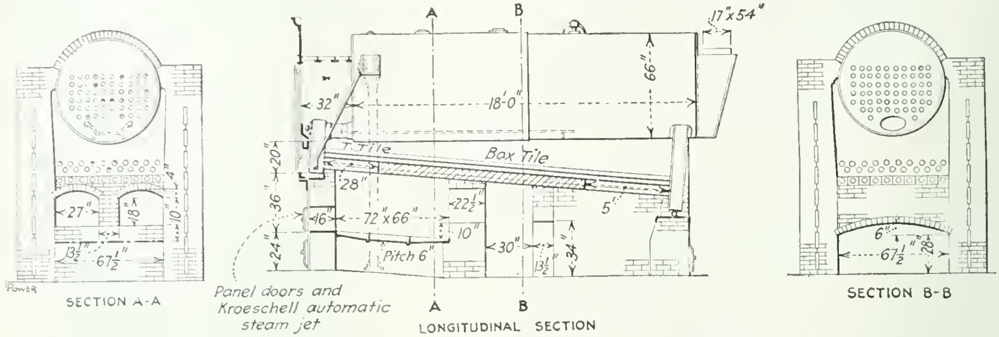

Fig. 5. Kroeschell Combination Boiler, Hand Fired

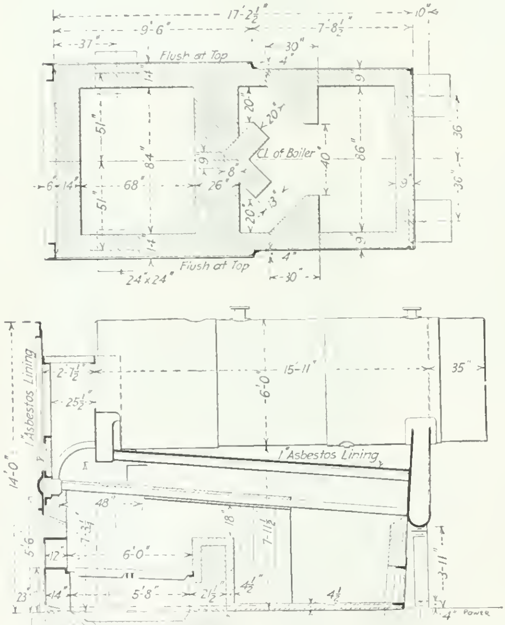

Fig. 6. Hawkes Boiler with Department No. 8 Setting

water-tube boiler provided with T- and box tile in the usual manner, a pigeon-hole bridge-wall and a single-span deflection arch in the combustion chamber. There are occasions, however, where these combination boilers have short water tubes. Fig. 6 shows a Hawkes boiler with tubes approximately 15 ft. long. It is not possible to get a flush-front, hand-fired setting under such a boiler with a deflection arch and leave sufficient room at the back end of the tubes. In such a case a furnace built on the order of the department No. 8 furnace, described in a previous article, will work out nicely. Fig. 6 gives all the working dimensions necessary for installing a flush-front, hand-fired setting for this boiler. The same furnace can be applied to regular horizontal water-tube boilers with 16-ft. tubes.

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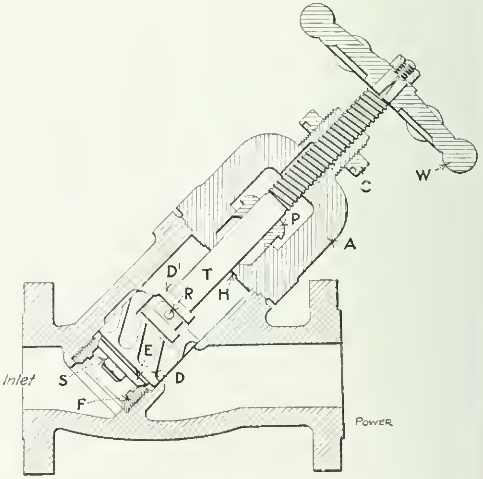
Powell Blowoff Valves

The illustration shows an improved Y-blowoff valve. The yoke top A is secured to the valve body by studs. The packing is held in place and tightened by the pusher gland P, which is moved by the outside screw nut C,



Section through Blowoff Valve

above the bridge yoke, enabling the pressure to be adjusted with an ordinary monkey-wrench; the connections are not shown. As the faces D' and H fit tightly, the valve may be repacked under pressure.

The plunger D is of brass, milled to receive the collar on the stem T. Spiral grooves are cast on the outer face, which, receiving the pressure from the steam as the valve is opened, cause it to revolve as it nears the seat when closing; this has the effect of keeping both disk and seat clean of scale and sediment.

The seat ring *F* has been dropped lower to better protect it from the cutting effect of the rushing steam as the valve is opened. To the plunger is attached a regrindable, reversible and renewable disk, *E,* which is secured by the disk nuts, shown. The disk face and seat bearing are at such an angle that sediment or scale cannot lodge between them, either while blowing off or closing down the disk.

To regrind this valve a wire pin or nail is inserted through the hole *R* in the plunger. This locks the disk which is then rotated back and forth after putting a little fine brick dust or sand on the seat. The seat ring *F* has two faces; when one is worn it can be removed and reversed by means of the lugs cast in the throat of the ring. The disk *E* is not only regrinding and reversible, but is also renewable, and guaranteed to stand a temperature of 2000 deg. F. The valve is made in 2- and 2½-inch sizes with screwed or flanged ends and tested to 250 pounds hydraulic pressure.

This valve is manufactured by the Wm. Powell Co., Cincinnati, Ohio.

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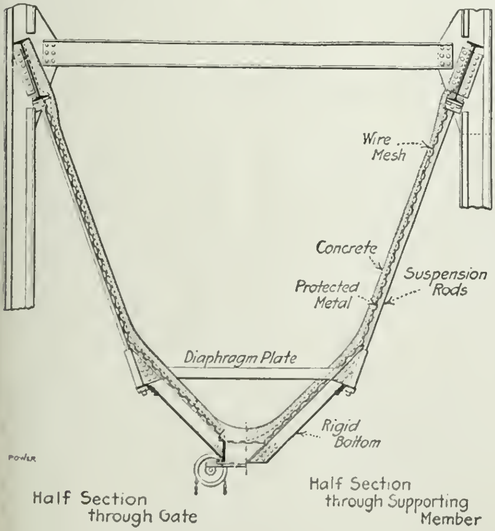
Baker Suspension Storage Bin

The design of the Baker coal-storage bin combines the principles of the suspension and hopper types of construction. The suspension rods and steel frames provide a flexible method of support as shown in the accompanying illustration.



Details of Coal-Storage Bin

The bin lining is of concrete laid on asbestos steel, a sheet metal protected by a coating of asphaltum and covered with asbestos. The sheet metal is impregnable against moisture and acids, and no metal is directly exposed to the coal.

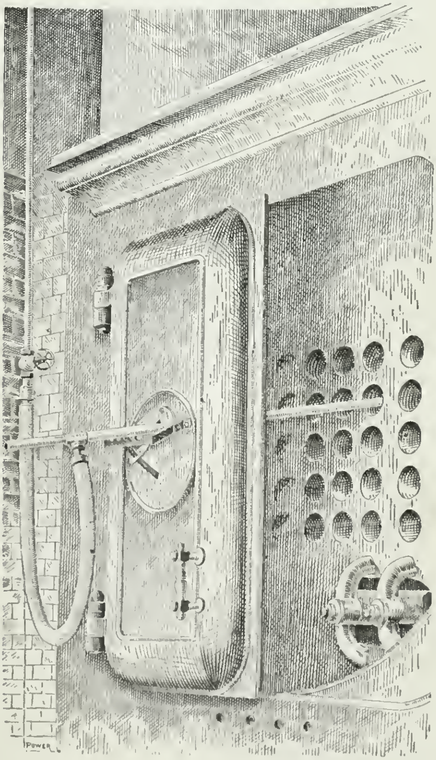
Breaking of the concrete lining, due to the slight bend in the supporting rods when the bin is loaded, is prevented by slats provided in the concrete, running at right angles to the suspension rods. The slats are filled with an asphaltum compound to prevent moisture from reaching the protected metal. The under side of the bin does not require plastering as the metal is protected by asphaltum-asbestos covering. The unit construction consisting of supension rods and bottom frame makes it possible to extend the bin structure when desired.

This bunker, which is built by Arthur G. McKee, Cleveland, Ohio, is also made with other forms of lining, such as unit slabs, varying in thickness from 2½ to 4 inches and wood.

⁂

Reiter Flue Blower

A flue blower, which will clean the tubes of a tubular boiler with the doors closed and without interfering with the draft or steam pressure, has been recently designed by the National Boiler Specialties Co., of Elgin, Ill. The blower is nothing more than an ordinary pipe with a special nozzle, a handle at the outer end and a tee which is connected to the steam line by a flexible hose. The blower enters the front compartment through a hole in either door, which are ordinarily covered by the pendants. It is guided to the various tubes in a horizontal row by means of the notches in the straps hinged to the doors and the vertical movement to the various rows is gaged by the



Reiter Boiler-Flue Blower

notches in the supporting legs which pass through slots in castings attached to the doors. In each strap there is a notch for half the number of tubes in a row, and in each leg a notch for each row. The notches are so spaced with relation to the hole in the door that the blower will enter the various tubes without any trouble. For each case it is necessary, of course, to know the horsepower of the boiler, number of rows of tubes and the number of tubes in each row.

When the blower is turned on, the soot is blown back through the tube against the draft. The heavier particles settle into the combustion chamber and the finer particles are carried back by the draft through the other tubes toward the stack. In this way no soot escapes into the boiler room and the boiler can be maintained in full operation as usual. It will be understood that one tube is cleaned at a time, so that while cleaning, the draft is obstructed in the one tube only and is on all the other tubes.

The Compression of Ammonia Gas

By G. H. Crawford, Jr.

The relations existing between the back, head and mean effective pressures during the cycle of compression of ammonia gas in the cylinder of a refrigerating machine are often not thoroughly understood. While these relations follow theoretical laws much more closely than the similar relations in a steam engine, they have not been given much attention and are less well known.

It is common knowledge among those familiar with refrigerating engineering that, speed and head pressure remaining constant, a rise of back pressure increases the load on the prime mover. This increase is evidenced by a longer cut-off on the engine or a greater current consumption by the motor, depending on the nature of the prime mover. As the load of a refrigerating machine consists mainly of the compression of gas in the cylinder, it is readily understood that the increase of load is caused by the increase of the mean effective pressure.

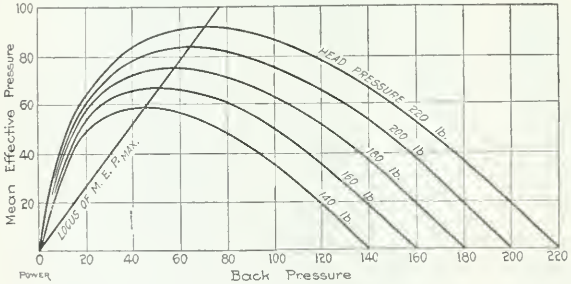


Fig. 1. Relations between Mean Effective, Back and Head Pressures

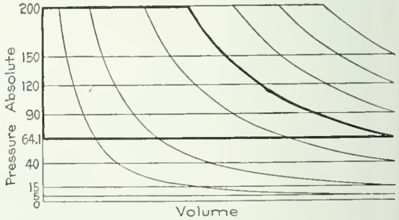


Fig. 2. Theoretical Ammonia Diagrams

On starting a refrigerating machine, especially if it is driven by an electric motor or an internal-combustion engine, whose characteristics make it necessary to have a low-starting torque, it is customary to bypass the two ends of the ammonia compressor, so that both sides of the piston are influenced by the same pressure—that of the condenser. By thus bypassing the gas, the machine is caused to start easily; in other words, a light load is placed on the prime mover. This light load proves that while pressure equalization exists, the mean effective pressure is low. When the pressures are thus equalized, the back pressure, acting on the piston, has been raised until it is equal to the head pressure.

When the two facts just mentioned are considered together, they are apparently contradictory. For the first might be written, the greater the back pressure, the greater the load. The second might be formulated, the greatest back pressure, the smallest load. The apparent contradiction is explainable. For any given head pressure, there is a certain critical back pressure at which the mean effective pressure in the cylinder is greatest. If the back pressure is higher or lower than this critical value, the mean effective pressure is less than the maximum. It happens that the compression of ammonia gas follows closely the theoretical laws. For adiabatic compression with no clearance, the mean effective pressure may be written:

$$m.e.p. = \frac{np}{n-1}\left\{\left(\frac{p_c}{p}\right)^{\frac{n-1}{n}} - 1\right\} \qquad (1)$$

where p is the back pressure, p_c the head pressure, and, for ammonia, $n = 1.3$.

For any assumed head pressure, p_c, it is mathematically possible to find the back pressure p_x at which the mean effective pressure (m.e.p.) is a maximum. The problem works down to the simple relation

$$p_x = 0.3204\, p_c \qquad (2)$$

wherein p_x is the back pressure at which the m.e.p. is greatest for the assumed head pressure p_c.

By combining relations (1) and (2), a third relation is obtained:

$$m.e.p._{max} = 1.3\, p_x \qquad (3)$$

From (3) it is easy to solve for the actual value of the maximum m.e.p. As an example, let the assumed head pressure be 200 lb. per sq.in. $= p_c$. Then

$$p_x = 0.3204 \times 200 = 64.08 \text{ lb. per sq.in.}$$

and

$$m.e.p._{max} = 1.3 \times 64.08 = 83.40 \text{ lb. per sq.in.}$$

(Absolute pressures are used unless gage pressures are specified.)

These calculations show that with a head pressure of 200 lb. per sq.in., the maximum load occurs at a back pressure of 64.08 lb. per sq.in. At this back pressure, the m.e.p. is 83.4 lb. per sq.in.

These relations are shown graphically in Fig. 1, where the coördinates are m.e.p. and back pressure. The different curves are for different head pressures. It is seen that each curve has a maximum point, before and after which the value of the m.e.p. is lower. It is also seen that the maximum points of the different curves fall on a straight line, whose equation is

$$m.e.p._{max} = 1.3\, p_x$$

All these relations are of value to the refrigerating engineer. With them he can predict the maximum load to be carried for any condition of head pressure. Thus, with a head pressure of 220 lb. per sq.in., there is a possible maximum m.e.p. of over 90 lb. per sq.in., while if the head pressure is only 140 lb. per sq.in., the maximum m.e.p. is less than two-thirds as much, and a prime mover whose ultimate power is in proportion may be used. The working power requirements also may be estimated from the curves. Thus, if the back pressure is to be 30 lb. per sq.in., the difference in the power required to run the machine at 220 and 140 lb. per sq.in. head pressure is nearly 36 per cent. This demonstrates the actual value of keeping the head pressure as low as possible.

In Fig. 2 these relations are shown in a different manner. Seven no-clearance diagrams have been plotted, each with the same head pressure but with different back pressures from 5 to 150 lb. per sq.in. The heavily outlined diagram, back pressure 64.1 lb. per sq.in., has the greatest area, hence the greatest m.e.p. The areas for very low and very high back pressures are obviously less than the areas with medium back pressures.

A knowledge of these relations is also valuable to the operating engineer. He should realize that the higher the back pressure, the greater the refrigerating capacity of the machine. Similarly, the power required per unit of refrigeration produced decreases as the back pressure increases. From a consideration of both capacity and economy, it is desirable to operate at as high a back pressure as possible. The temperature in the refrigerator is the limiting factor, for this rises with an increase of the back pressure. By increasing the heat-aosorbing surfaces in the refrigerator, it is often possible to maintain the desired temperatures at somewhat higher back pressures. The problem then reduces itself to the familiar one of balancing first cost and operating economy.

For a long time, the most common back pressure used in refrigerating and ice-making plants has been about 15 lb. per sq.in. gage. In some of the more recent installations, especially in those driven by high-priced internal-combustion engines, it has been found advisable to so increase the expansion or refrigerator side that the operating back pressure is 20 to 25 lb. per sq.in. gage. By so doing, smaller engines and compressors may be used and higher economies obtained than under the old arrangements. The added first cost of the expansion side is partly balanced by the decreased cost of smaller engines and compressors.

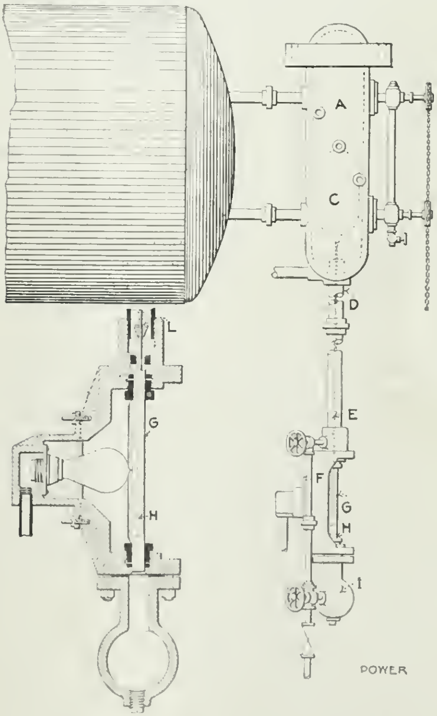
In pumping out any part of the refrigerating system in which there is considerable ammonia, as, for instance, a stand of condensers or liquid receiver, it might be advisable to allow nearly the full pressure to come on the suction side of the compressor, instead of throttling in the usual way. The m.e.p. would not be higher than for a much lower suction pressure, while the capacity for pumping out would be greatly increased and the time for the operation reduced.

It should be noted that in practice the values of the mean effective pressures are usually slightly less than shown in Fig. 1. This is due partly to clearance, of which all compressors have some, and partly to the fact that the compression of ammonia gas does not follow exactly the adiabatic curve of which $n = 1.3$. With leaky discharge valves, however, it is possible to obtain mean effective pressures higher than those shown.

*

Hydraulic Extended Water Column

In many boiler plants the water-glass is so high from the floor that it is difficult for the firemen to tell the water level accurately.



Details of Extended Water Column

The extended water column illustrated is designed to bring a water-gage level with the firemen's eyes. The device consists of a water column A, piped to the boiler in the usual way. Inside is a float C, connected to an indicator rod *E*, in the extension pipe *D*, to which is screwed an extension gage casing *F*.

On the lower end of the extension rod *E* an indicator *H* travels up and down in the extended gage-glass at *G*. An inclosed electric light illuminates the indicator *H*.

If the lower glass breaks the apparatus cuts itself out by the check valve *L* seating, when the glass can be replaced; the upper gage-glass is, however, available. This device is made by the Edwards Steam Specialty Co., 343 South Dearborn St., Chicago, Ill.

* *

Massachusetts Boiler Law and Rules--I

By C. J. Andrews

SYNOPSIS—Critical analysis of the Massachusetts Boiler Law and the Rules laid down by the Board of Boiler Rules. This will appear in three installments. This first one discusses the law and the rules up to Part III. The rest will be treated in subsequent issues.

*

Since the Massachusetts Boiler Law and Rules have been used as a pattern by several other states and largely copied in the uniform boiler law proposed by the American Society of Mechanical Engineers, to be generally adopted to govern the construction and operation of steam boilers, a discussion of the good points as well as the defects that have appeared in their practical application may be of interest. Some parts of the law and some of the rules have proved to be good, while others work hardships, or at least seem unnecessary and inadvisable.

The general scheme of the Massachusetts law providing a board to formulate the rules and change them whenever advisable, is good. This should be adopted in any boiler laws enacted, for flexibility in the rules is a necessity. Rules cannot be made that will not require changing from time to time. Many changes have been made in the Massachusetts rules since they were first drawn, but if the board has erred in exercising this authority, it has been in not making enough.

Massachusetts Law

Section 1 of the law specifies the kinds of boilers that are exempt from inspection and provides that other boilers in the state are to be inspected once annually. It also provides for uninstalled boilers that were in the state at the time of the passage of the act, but which did not conform to the rules. The provisions of this section seem to be proper and well chosen.

Sections 2 to 5 inclusive deal with inspectors and how inspections are to be made and the reporting of boilers to the inspection department of the state by the owners. Nothing in these sections is superfluous and they may well be followed.

Section 6 indicates how inspectors in the employ of insurance companies may become qualified to inspect boilers for use in the state. While its wording shows no defects at a glance, several have become apparent by the enforcement of the law. In the first place, three members of the state inspection department are designated to act as a board of examiners of inspectors of equal rank, for the insurance companies. This is not customary in making any similar appointments under municipal, state or national government control. The qualifications of candidates for inspectorship should be determined directly by the board of boiler rules, or at least the examinations should be under the board's supervision. This is done in Ohio; examinations are held at regular intervals by the board of boiler rules.

Another faulty feature is that the examination of the applicant is entirely oral. An examination without definite indication of the right and wrong answers is not satisfactory to an applicant who is refused a certificate, and its fairness can never be above suspicion. Ohio holds written examinations and the papers are marked and turned in, so that the applicant may know his standing.

A third defect of this section is that the certificate is revocable, not only for cause, but also if the holder should leave the company by whom he was employed when he secured it, and a re-examination is necessary to secure a new one. Why this should be is difficult to see; an inspector's qualifications are not affected by merely transferring his services from one company to another. Here again the Ohio law, although generally patterned after that of Massachusetts, is superior. It does not require that an applicant be employed or even intending to enter the employ of an insurance company or the state department, before he may take an examination, and his examination is only to determine whether he is competent to make boiler inspections. If so found, he is granted a certificate, which does not give him the right to inspect boilers, but only to apply to any insurance company or to the state inspection department for a position. They can engage him without delay, knowing that he will be granted a commission upon request. If an inspector changes from one company to another, it is only necessary for his new employer to request a new commission for him.

Under the Massachusetts law, the applicant must first secure a position as inspector, or the promise of one, and then appear before a board for an oral examination. If he fails, he probably has no idea why he was considered incompetent. He may appeal and be re-examined orally by five examiners chosen from the same inspection force, whose findings are final. The law provides that no one of the first three examiners may act on the board of appeal; but does this safeguard the interest of the applicant sufficiently?

Section 7 provides, in granting an appeal from the decision of the first examiners, that the applicant may have a representative of the company by whom he is or is to be employed present during the examination. Under the Ohio law, one whose certificate has been revoked may have counsel at the hearing of an appeal, and is able to learn whether he has had fair treatment.

According to Section 6, ninety days must elapse after an examination before an applicant may take a new examination, except in the case of appeal. This in itself would be all right if an inspector could change from one company to another without losing his certificate, but it may be a hardship. In one case, an inspector lost a position with one company, through no fault of his own, and because he had been recently examined, and although passed, he could not be re-examined until the expiration of the prescribed 90 days. He was worse off than if he had been found incompetent, for then he could have appealed and taken a new examination at once.

All the provisions in *Sections 8 to 15* inclusive are apparently needed and seem properly drawn to accomplish the desired end.

Sections 16 to 19, inclusive, seem necessary and in order and should be copied by other states.

Section 20 deals with fusible plugs; no very serious objection may be made to this section except that lead is specifically mentioned as one of the metals to be used for filling such plugs, whereas tin is considered better. It would seem best to have left the specification of fusible plugs to the board of boiler rules.

Section 24 is the next deserving comment. It provides for the appointment of the board of boiler rules and wisely selects them from the boiler-inspection department, the boiler-using interest, the boiler-manufacturing interest and the boiler-insurance interest, with one member an operating engineer. Selecting members to represent these various interests is an advisable plan for a state or municipal government to follow. It would also seem wise to specify that the members must be well versed in the operation and construction of steam boilers. The object of the board being to modify old and make new rules to govern the construction and operation of steam boilers, its members should be thoroughly conversant with the subject.

Section 26 prescribes the duties of the board of boiler rules and wisely provides that public hearings be held twice a year to consider petitions for changes in the rules. A good requirement in this same section is that any changes in the rules, even if proposed by the board, must be advertised, so that the public may have knowledge of those contemplated before they are actually made. Provision that changes shall take effect six months after they are approved by the governor of the state prevents working a hardship on the manufacturers or purchasers of boilers who may have contracts in process of completion. Where a manufacturer wishes to make a special type of boiler, he must submit drawings to the board for its approval. Probably it would be well if this rule applied to all boilers to be constructed for use in the state. The plans submitted could be given a designating number, and as many boilers as were desired could be made from these plans with the certainty that they would meet the requirements of the law, as long as the material used and the methods of construction complied with the law. The province of Alberta, Canada, has a rule to this effect which is found to be convenient and tends toward the standardization of boiler design.

The rest of the law, including Section 30, seems to be just and proper and to need no criticism.

BOILER RULES

The division of the rules into three parts is admirable and should be adopted by others. Nothing hinders the enforcement of any law so much as to have it conflict with the property rights of the citizen. Recognizing this, different rules were prescribed for boilers installed and in use before the law went into effect. These constitute part one. The rules in the second part apply to boilers already in the state as well as to new boilers that are to be entered after the passage of the law. The third part is composed entirely of rules that apply to boilers to be installed after the passage of the law and contains by far the most rules.

PART I OF THE RULES

This part is very short, consisting of a single section.

Paragraph 2 specifies that 55,000 lb. tensile strength for steel and 45,000 lb. tensile strength for iron shall be assumed when the actual values are not known. This is a wise rule, for it is conservative and gives the inspector definite authority as to what he may do under certain conditions. Unless a rule of this kind is inserted, there is continual wrangling between the inspectors and the boiler owners as to the correct value to be used in each case.

Paragraph 3 specifies that the factor of safety for butt joint boilers shall be 4.5, which is 0.5 less than the factor of safety required for new boilers of similar construction. While it is illogical from purely a mechanical standpoint to permit a higher pressure on an old boiler than on one just built, the interference with the property rights of the citizen is of more importance than the slight difference in the safety factor. Boiler construction in Massachusetts was in advance of that in most other states when this law was passed, and the pressures allowed on the boilers in that state were on a higher factor of safety than in many other states, hence prescribing a factor of 4.5 for butt-strapped boilers was not a hardship on the owners. When Ohio passed a boiler law, the safety factor on boilers already in use was fixed at 4 as a minimum, and the inspector was permitted to raise the limit where he thought it necessary to secure safety.

Paragraph 4 prescribes a method to be used to determine the size of rivet holes, when their size cannot be directly determined by measurement, by specifying the various sizes that are to be assumed for the different plate thicknesses. This rule is very commendable and is in keeping with the rule specifying the tensile strength to be assumed for unknown plate.

Paragraph 5 undertakes to specify the arrangement of safety valves for boilers under various conditions, and seems to be unnecessarily cumbersome to attain the desired end, i.e., safety. A rule requiring all to have a given area of safety valve for a given area of grate and a fixed pressure, and prohibiting two boilers operated at pressures differing more than 100 per cent., being connected to the same pipe system, would have been much simpler and probably provided greater safety. The present rule relies on the safety valve of an equivalent area to the connecting pipe, to prevent an excess pressure coming on the low-pressure boiler or boilers, while it is well known that the relieving capacity of a safety valve is not nearly so great as its nominal size would indicate. This fact is made evident in the formula given in the same rules for estimating the size of safety valves to perform a given duty.

PART II, SECTION 1

Part II, as has already been stated, applies both to the boilers installed at the time that the law went into effect and to the new boilers to be installed in the future.

Paragraph 1 correctly limits the pressure on boilers constructed wholly of cast iron to 25 lb., and there is also a proper provision in *Paragraph 2,* limiting the pressure on boilers using cast-iron headers to 160 lb.

Paragraph 4 specifies that the resistance of boiler plate to crushing is to be taken at 95,000 lb. per sq.in. This rule might have been omitted, for the value of the crushing strength of steel plate is very uncertain and only comes into play with practical boiler seams on double-riveted joints where the outside straps are narrower than the inner straps. The omission of this factor in the calculation of the strength of boiler joints would have simplified the subject considerably and detracted nothing from the safety of the rules. The shearing strength as given in *Paragraph 5* follows the customary values used for this purpose by nearly all the modern authorities.

Paragraph 7 gives the factor of safety to be used on boilers, the shells of which are constructed with lap longitudinal seams, these factors running from five to six on externally fired boilers, dependent on their age, and five for boilers, the shells of which do not come in contact with the products of combustion. While this grading of the safety factor was all right for Massachusetts, it would hardly do for any other state. The customary minimum factor for boilers throughout the United States may be said to be 4; and while it would be better 5, such a change applied to boilers already in use would invade the property rights of many owners. The factors adopted by Ohio seem more logical.

SECTION 2

The criticism of Paragraph 5 of Part I applies the same to *Paragraph 2* of Section 2 of Part II. Limiting the difference in pressures to be permitted on boilers connected to the same steam-pipe system would better guard against over pressure on the low-pressure boilers of such a system.

Paragraphs 3, 4, 5 and 6, relating to safety valve areas, are standard and require no changes.

Paragraph 7 could be improved by specifying that in new installations the safety valves should be placed not to exceed a given distance from the boiler and on a separate and independent connection; there should be more specific and complete directions as to the proper support and anchorage for escape pipes when used on safety valves.

Paragraph 9 could be improved. Limiting the safety valve size to 5 in. is good, but requiring the seats of all safety valves to be beveled or inclined to the center line of the spindle about 45 deg. is not; some of the best safety valves made have flat seats. A requirement that the boiler owner must see that the lifting device specified for such valves is in place at all times, and that the engineer in charge of the boilers should see that each safety valve is tested once a day, would increase safety of boiler operation. The locations of fusible plugs, as specified in *Paragraph 11,* are good except for vertical tubular boilers. There a fusible plug is practically useless and often causes serious trouble.

Paragraph 15 might be improved by specifying that the 1/4-in. connection for the inspector's test gage have a siphon which can be filled with water to avoid injury to the gage, from steam coming in contact with the spring. There was probably no logical reason for specifying two gage cocks for boilers operated at pressures below 25 lb. and three for boilers operating at higher pressures, as specified in *Paragraphs 17 and 18,* except to avoid too great an interference with boilers already installed; if this was the purpose the rule is fully justified.

Paragraph 19 is a good rule except that the feed water must be discharged below the lowest safe water line. This rule bars the steam space feed, which is widely used in some sections of the country, and is one of the best methods. The last sentence of this paragraph states that means must be provided for feeding a boiler with water against the maximum pressure allowed on it. The cause of safety would have been aided if some other means of feeding a boiler had been required besides the pressure from a water-works system, except for heating boilers operating at pressures below 25 lb.

If the water-column connection to the steam space of a boiler can be considered a steam outlet from the boiler, *Paragraph 20* should have been modified to exclude a valve on such connections, for evidently the rules intend to discourage using valves there, and they should.

Paragraph 22, if strictly adhered to, would have the damper regulator connected directly to the steam space of the boiler, while later in the rules the top water-column connection is specified as a suitable place for attaching it.

Paragraph 23 specifies that where furnace mouth-piece protectors are used and valves are placed on the pipes connecting them to the boiler, such valves shall be locked open. The safety of such an arrangement would be increased if safety valves were required for such attachments when valves were used on the connecting pipes, these safety valves to be set 20 lb. in advance of those on the boilers.

SECTIONS 4 AND 5

are proper and serve admirably the purpose for which they were intended.

SECTION 6

Paragraph 1 of this section would be improved if, when a power boiler is to be tested by hydrostatic pressure and is connected to a steam main in service at the time, it required two stop valves between the boiler and the steam main, or, if only one valve is used, breaking the connection with a blank flange before the test. Serious accidents have occurred in this way, since the strain on the valves, due to expansion and contraction of the parts on account of the unequal temperatures on each side of the valves, is very severe.

SECTION 7

The only comment to be made on Section 7 is that it would have been better if the method used for calculating the efficiency of boiler joints had been placed in an appendix, since the matter contained is in reality not a rule laid down by the board of boiler rules, but simple instructions on how the efficiency of boiler seams is estimated.

In *Paragraph 6* of this section, which explains the calculations for a quadruple-riveted joint, those given under "D" for the strength of the joint, considering the breaking of the net section of the plate through the second row of rivets, could have been omitted to advantage since this kind of a failure is never concerned with the efficiency of a boiler joint where rivets of uniform size are used.

SECTION 8

This section deals with the kind of certificate to be issued and how it is to be posted by the owner of the boilers inspected. Its prescribed wording is such that a separate one must be issued for each boiler, unless all boilers are exactly the same and have been inspected on the same day. This duplication of certificates in the average plant is not important, but in large boiler houses a scheme for designating the boilers by numbers and dating the certificates by months only, would go a long way toward simplifying the subject, without detracting from the efficiency of the service.

Cracked Headers on a Water-Tube Boiler

At Detroit, Mich., a slight leak was discovered at the front header of a Geary water-tube boiler while under steam. The boiler had been operated at 185 lb. for 12 years.

The front cap and rear tube plates had cracked at each of the curves of the flange for a distance of nearly 2 ft., as shown in Fig. 1, which was made from a photograph of the reflection on a mirror inserted between the tube and hand-plate sheets, showing the crack on the inside of the front plate at the bend. The tube sheet was cracked at both sides in a similar manner, as shown by the plan drawing at the right.

The boiler had a steel drum 18 ft. 8 in. long by 24-in. in diameter, made of ¼-in. plate with an 87 per cent. joint. The tube and outer sheets were of $\frac{7}{16}$-in. plate, with 1¼-in. stay-bolts pitched 4½x5 in. The wrapper plate connecting the tube and the other plate was only ⅜ in. thick and was 6 in. wide from the rivet holes, center to center, the distance between the tube and outer sheets being 10 in.

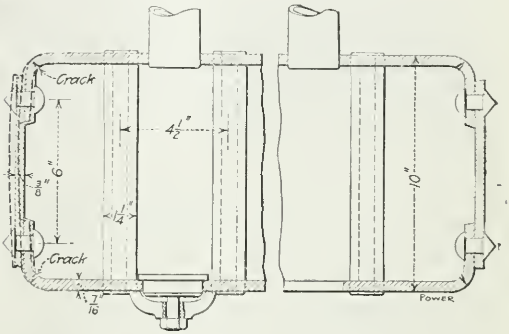


FIG. 2. SHOWING CRACKS IN CURVES OF PLATES AND THE CURVATURE ASSUMED BY WRAPPER PLATE

The failure, which fortunately did no damage, was due to the inherent weakness of the ⅜-in. wrapper plate (see Fig. 2). The front and tube sheets are held together by stay-bolts, and the wrapper plate makes a tight joint between the two plates. Suppose a piece of thin sheet iron were riveted in place instead of the ⅜-in. wrapper plate, and steam pressure were applied from the inside, but not enough to tear the sheet iron away; the thin sheet would bulge outward. If a thicker piece were used, strong enough to resist the 185 lb. pressure carried on the boiler without rupturing, but not strong enough to remain in its original position, it would tend to assume the same curved and bulged position as the thin sheet. Owing to its difference in strength, however, it would cause the flanges on the front and tube sheet to bend at the curve of the sheets, as shown by the dotted lines, Fig. 2. This bending would eventually result in a crack, as shown in Figs. 1 and 2. A wrapper of proper thickness would prevent the bending of the plates at this point with the changes in boiler pressure.

This boiler, aside from the weak wrapper plate, was reasonably safe for 185 lb. pressure, but should not have been allowed to carry over 100 lb., because of this weak point in its design. A micrometer measurement of the deflection of the plate measured 0.023 in. at 185 lb. working pressure and 0.39 in. under a hydrostatic pressure of 50 per cent. over the working pressure.

This case exemplifies the danger of hidden defects. It was impossible to have access to these plates without tearing down the brickwork, and their thickness could be determined only by drilling or removing a rivet. The advantage of boiler inspection during construction is emphasized by the failure.

Drying Out Oil-Immersed Transformers

By H. M. McLellan

SYNOPSIS—The usual methods for drying out transformers and transformer oil, with practical suggestions to guide the operator in carrying out the work.

⁂

Oil-immersed transformers should be dried out before they are connected to the circuit, in order that every trace of absorbed moisture may be removed. The transformer and the oil should preferably be dried separately, the transformer at a temperature of 80 to 90 deg. C. (176 to 194 deg. F.), and the oil at a temperature of from 100 to 110 deg. C. (212 to 230 deg. F.).

The simplest way to dry the transformer is to short-circuit one of the windings, generally the low-tension one, and connect the other to an alternating-current supply, with a voltage of from 1 to 5 per cent. of that for which this winding is arranged. The voltage must be such as to set up a suitable drying current in both windings of the transformer. This current varies with the size of the transformer, and is approximately as follows:

	Normal Current
Transformers up to 5 kv.a.	1½
Transformers 5 to 20 kv.a.	1¼
Transformers 50 to 200 kv.a.	1
Transformers 50 to 200 kv.a.	0.6
Transformers 200 to 500 kv.a.	0.4
Transformers above 500 kv.a.	0.2

These figures are intended to serve only as a guide as the current necessary to obtain the desired results varies considerably with the type of transformer. In every case, the following points should be carefully attended to and the current adjusted accordingly:

Place two or more thermometers in such a way between the windings that the bulbs directly touch the insulation of the copper. It is not sufficient if they touch only the insulation washers, etc., as the temperature of these parts, as a rule, is considerably lower than that of the insulation immediately around the conductor. These thermometers should be securely held in place by waste, but care must be taken that nothing intervenes between the bulbs and the insulation.

The current should be adjusted to give a steady temperature of 90 deg. C. If it is not possible to adjust the current accurately and if the temperature rises above 90 deg. C., the current must be switched off until it falls to about 80 deg. C., otherwise the insulation may be damaged. The current should then be switched on again, then off, and so on throughout the whole period of drying. Be careful not to break the thermometers, as drops of mercury might stay between the windings and cause trouble.

It is preferable to dry the transformer outside the tank, as it is then easier to get rid of the moisture and control the temperature. This is important, as any indications of excessive temperature which may occur are much more apparent when the transformer is outside than when it is inside the tank. For instance, if the thermometers are not placed correctly, the real temperature of the transformer will be considerably in excess of that shown; and parts of the windings may reach an excessive temperature as indicated by smoke and the discoloration of the insulation. If there are any evidences of such excessive temperatures, the current must be switched off immediately, and the drying afterwards continued with less current. In no case must the transformer be left without attention during the drying process.

The drying out in air should be continued from 6 to 12 hr., at least, after a temperature of 80 to 90 deg. C. has been reached. In the case of large transformers (above 500 kv.a.) for high voltages (above 10,000 volts), the drying should be continued for 24 hours. The time necessary depends upon the size of the transformer and the temperature obtained.

In case the available voltage is too high to be connected directly to the transformer, as described, a resistance may be put in series with either the high-tension or low-tension windings, depending upon the resistances available, as both the current and the voltage to be taken up by the resistance varies according to the ratio of the transformer.

Another alternative is to connect the high-tension or the low-tension windings of several similar transformers in series, so as to give each only a portion of the supply voltage. Only the windings to which the voltage is applied need be connected in series, the other windings being short-circuited on themselves. This series connection is not feasible with three-phase transformers, however, unless the windings can be separated.

Still another method of drying, if low-voltage current is unavailable, is to place the transformer in its tank and pass heated air over the coils. In this case a good circulation should be maintained.

The oil may be dried independently of the transformer, either by external heat, by blowing heated air through it, by means of electrical resistances inside the tank or by passing it over unslacked lime. If the first method is used, caution is necessary in order to prevent ignition. The oil should be kept at about 110 deg. C. (230 deg. F.) for about 12 hr., or longer if the temperature is lower than above.

If there are no means of drying the oil separately, it may be dried with the transformer. In this event the transformer, after having been first dried separately, is placed in its tank of cold oil and the current switched on again. When the transformer is in the oil, however, the current should be about 50 per cent. above full-load current. The temperature must be watched by means of a thermometer in the upper layer of oil, and this part of the oil should be heated up to 110 deg. C. (230 deg. F.). When this temperature is reached, the current should be switched off until the temperature drops to 90 deg. C., then switched on again, this operation being repeated until the oil has been kept heated for 12 hr. or more.

When the oil is heated by means of the transformer itself or by resistances placed in the oil, it should, if possible, be stirred at frequent intervals in order to bring the cool oil at the bottom to the top, where it can be heated more quickly. In order to shorten the time for drying, the tank should in all cases be lagged to prevent radiation; this also greatly reduces the amount of current necessary. The tank cover must be removed during the drying process in order to allow the vapor to pass off.

There is still another method in which the transformer and the oil may be dried together. This is by means of internal heat through the transformer coils in conjunction with a vacuum in the tank. Owing to the necessity of a vacuum pump and the difficulty of keeping the tank vacuum-tight, this method is not so well adapted to ordinary conditions.

With small transformers for comparatively low pressures, the oil should be dried for about 12 hr., as described. With transformers up to 500 kv.a. and 10,000 volts, the drying should occupy up to 24 hr. In the case of still larger transformers and higher pressures, it is sometimes advantageous to extend the drying over three or four days, it being advisable to allow the transformer to cool down to room temperature once or twice during the process.

When the low-tension winding is short-circuited, and a current at comparatively low voltage is passed through the high-tension winding, there will be no danger of excessive pressures in the windings. If however, current is brought in on the low-tension side, a dangerous pressure may be induced in the high-tension side, especially if the short-circuit should be broken by accident. Special care must, therefore, always be taken to insure that the short-circuit is never broken before the transformer under test has been disconnected from the supply circuit.

Patching Boilers

By S. Regral

SYNOPSIS—Practical points for measuring boiler patches, a method of riveting them and why different-shaped patches are used.

⁂

The problem of laying out a boiler patch is simple, and but few points need be borne in mind. The defective portion of the plate must first be removed, but no more than is necessary, so as to keep the patch as small as possible. A circular-shaped patch is the best when practical, as it weakens the shell less than one having a straight seam and is less likely to give trouble from leakage, which often occurs at the corners of a rectangular patch.

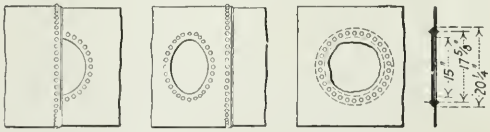
In all cases, the straight portion of the longitudinal seam should be as short as it can be made, and that portion of a single-riveted patch should never exceed 24 in. in a boiler carrying a pressure of 100 lb. or over. If a triple-riveted, butt-strapped boiler is designed to carry 125 lb., and a single-riveted patch of large size is put on, it becomes at that particular point a single-riveted, lap-joint boiler. Of course, the surrounding portion of the boiler, being stronger, tends to reinforce the weakened part, but the extent of this weakening depends on the length of the straight portion of the side seam.

It is usually considered impractical to double rivet a patch, because patches are nearly always in the part of a boiler exposed to the most intense heat, and it is generally believed that a double-riveted patch cannot be kept tight under these circumstances. The stress on the longitudinal seam is the greatest and that on the circumferential seam is the least, consequently the more nearly the seam of a patch approaches the circumferential seam, the less is the strain on it.

A practical illustration is the case of the ordinary horizontal return-tubular boiler as usually built for pressures up to 150 lb. A single-riveted girth seam is sufficient, although a triple-riveted, butt joint is necessary for the longitudinal seams. It is partly for this reason that patches are so often of the familiar horse-shoe type, Fig. 1. This shape is used for patches close to the girth seam. There is no straight side seam, and, therefore, the boiler is not weakened to any extent, provided the patch is not large.

When a patch is put on the middle portion of a sheet the shape shown in Fig. 2 is used, and there is no straight side seam.

These two forms are used when the patches are comparatively small, but if the bulge is large, the side seams sometimes become as much as 3 or 4 ft. long. The side seams must necessarily be straight, and this portion of the boiler virtually becomes single riveted; the pressure allowed on the boiler must be reduced accordingly. The proper thing to do under such a condition is to cut out the sheet to a trifle above the fire line and put in a new section, riveted to the original side seam on one side and having a seam of the same design on the other side. While this does not weaken the boiler, it is an expensive repair, because of the large patch and the extra labor for chipping and riveting and the removal of more or less brickwork.



POWER FIG. 1 FIG. 2 FIG. 3 FIG. 4

Boiler Patches

To illustrate the method of laying out a patch, it is assumed that the fire sheet of a 72-in. boiler ½ in. thick is bagged about half-way between the front head and the bridge-wall. There is a 10x15-in. manhole in the front head below the tubes, and to just remove all of the defective plate a circle 15 in. in diameter will have to be cut out.

The patch should be placed on the inside of the shell. This is not to avoid the probability of it blowing off, as is sometimes supposed; there is no danger of this, even though the patch were on the outside, the rivets being amply strong to prevent it. The reason is to avoid the formation of a pocket in which sediment can collect, with the attendant danger of burning the patch.

The bag is shown in Fig. 3 by the irregular lines, the dotted line indicating the 15-in. circle it is necessary to cut out. The rivet holes must be punched or drilled around the outside of this circle, and it is customary to allow one and one-half times the diameter of the rivet from the edge of the plate to the center of the rivet hole. As this plate is ½ in. thick, ⅞-in. rivets will be used. This will bring the center of the rivet hole 1$\frac{5}{16}$ in. outside of the 15-in. circle, making the diameter from center to center of the rivets 17⅝ in.

In the patch it is necessary to allow one and one-half times the diameter of the rivet, or 1$\frac{5}{16}$ in. from the center of the rivet hole to the edge of the plate, making the total diameter of the patch 20¼ in. This is shown in Fig. 4.

This patch will not pass through the manhole, yet good practice demands that it be put on from the inside. The way to do this is to make both the patch and the opening in the boiler elliptical, as in the case of a manhead, and pass the patch through the opening. In doing this, the long axis is placed girthwise of the boiler so as to weaken the shell as little as possible. The long axis must be at least 20¼ in., say 20½ in. long, to allow the patch to enter easily. Adding one and one-half times the rivet diameter from the edge of the opening to the center of the rivet hole, and one and one-half times the rivet diameters again from the center of the rivet hole to the edge of the patch—a total of three rivet diameters to each end of the patch—makes the long axis 25½ in. long.

The opening in the boiler shell will be 15x20½ in., and the patch is 20¼x25½ in. It is passed to the inside of the boiler through the opening just as a manhead is passed through the manhole, then turned into position, and bolted in place while the riveting is being done.

There is an all too common practice of patching boilers as a result of bags. Probably 75 per cent. of the patches applied to boilers could have been avoided by properly setting the bulges back. This is not only cheaper than a patch, but is to be preferred, as it does not weaken the boiler and all trouble due to leakage and fire cracks is avoided.

There is a frequently expressed opinion that if a sheet is once bagged and set back, it is apt to bag again in the same spot. This contention is not supported by practice, as the metal is practically as thick as it was before it bagged, and would bulge again only when overheated, caused by another accumulation of sediment or grease. The original bag occurred at a point where sediment was deposited, and if more accumulates it will do so in the same spot and another bag will result, but not because the sheet has once been bagged and set back. This action is just as likely to occur on a patch as it is on a sheet which has been set back.

A troublesome feature in connection with patches is the formation of fire cracks extending from the rivet holes to the edge of the plate. They gradually grow worse, and open up until the leakage becomes such that it is necessary to remove the patch and put on a larger one. Although these cracks are by no means confined to patches, they are also prevalent around the edges of patches on the fire sheets, at the girth seams over the fire, and around the fire-door frames of some internally fired boilers. It is generally conceeded that they are caused by the cold air striking these seams when the fire-doors are opened, thus producing severe stresses. There are many boilers, however, operated under identical conditions in which there are no fire cracks.

It was generally thought that a double-riveted patch cannot be kept tight over the fire, but the writer is convinced that such a seam may be used year after year, and that all trouble from fire cracks may be avoided by putting the patch on properly. An extensive experience with boilers of all sizes and thickness of plate, is evidence that the trouble is due to the use of the drift pin. When the rivet holes do not come fair, and are forced into line with the drift pin, the metal is strained beyond its elastic limit and is under a severe initial strain with no elasticity to care for those of regular service; therefore leakage and cracks soon result.

The trouble is avoided by drilling all rivet holes in place rather than punching them, or punching them at least ¼ in. under size and then reaming them. The edges should be slightly chamfered to remove the burrs and minute cracks radiating from the hole A number of large patches have been put on in this way in plates up to $\frac{7}{16}$ in. thick and exposed to the direct action of the fire and they have held tight for years under regular operating conditions. This work costs considerable more than the usual method, but it is money well spent and will save dollars in repairs.

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Pyro-Perolin Boiler-Cleaning Process

The Pyro-Perolin process for keeping boilers free of scale, consists of an apparatus which generates and combines various gases in such proportions that when they are ignited and the flame is applied to the scale, which has been previously treated with Perolin, the combination decomposes and disintegrates the scale, leaving the metal clean, even in inaccessible parts.

Cleaning a boiler by this process requires from one to three days, depending upon its size, condition and type. After it is cleaned a liquid protective film is applied to fill the pores of the metal and establish a smooth surface, to prevent scale-forming sediments adhering. This film is maintained and the boiler kept in a clean condition by feeding daily a small amount of Perolin metal treatment.

The manufacturer, The Perolin Co. of America, 1112 W. Thirty-seventh St., Chicago, Ill., guarantees to clean any type or size of boiler by its process and free it from scale in not more than four days, without damaging the boiler, the setting or the attachments. The boiler is subject to the inspection and approval of the boiler-insurance companies. The company also guarantees to protect the boiler metal against pitting, corrosion and galvanic action, regardless of the kind of water used.

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Denatured Electricity—An interesting method of preventing the improper use of electric current has been devised by an Italian engineer. The practice of making especially low rates for current to be used in electric power, heating and cooking devices is becoming more and more general, but with the ordinary constant potential current it is difficult to detect the use of lights on circuits intended only for power and heating. This engineer advocates the use of special circuits on which the current is subject to extreme fluctuation of voltage at rapidly recurring intervals, which would make it practically impossible to use lamps, because of the flicker. As the current is not entirely interrupted and the normal voltage is almost instantly stored, the proper operation of power or heating apparatus is not interfered with and the rightful use of the circuits for their respective purposes is assured.

Editorials

The Indiana Boiler Law

We have before arisen to remark upon the carelessness with which statutes and ordinances are sometimes drawn. The present expostulation is the result of a reading of the Steam Boiler Inspection Law enacted by the General Assembly of the State of Indiana something over a year ago.

In section 8 it is decreed that:

> The bracing and staying of flat surfaces shall be so designed that seventy-five hundred (7500) pounds per sq.in. shall be the maximum pressure allowed.

Of course, the intent is that the maximum pressure allowed shall be such as will not stress the stays over 7500 pounds per square inch of cross-section, but that is not what the statute says.

In the same section occurs the following paragraph which we commend to the analytical scrutiny of our readers:

> All manholes shall be above the tubes in boilers fifty-four (54) inches, and above in diameter shall be placed in the top of the shell, and to be made of pressed steel.

Section 10 fixes the factor of safety of new "Indiana Standard" boilers at not less than five, with rivet holes punched at least one-eighth of an inch smaller in diameter than the rivet holes desired, and the rivet holes reamed out. "All boilers now in service of lapped longitudinal seam construction shall be allowed a factor (*all* boilers *a* factor) of safety as an examination of design and construction warrant, but not less than 5½." Boilers already built with butt-strapped longitudinal joints with two straps, may have factors of safety of not less than five. Boilers having longitudinal butt joints with but a single strap, will be treated the same as lapped-joint boilers. These factors of safety are all considerably high, and one can readily see where a manufacturer who has put in a boiler adapted to his work, with factors of safety in ordinary use before the passage of the law, will find himself out of tune with the department when it tries to reduce the allowable pressure anywhere from twenty to thirty per cent.

In the formula given in Section 21 for determining the safe working pressure for surfaces not self-supporting, with screwed stays riveted over, it is evident that the legislators or the printer have forgotten to put an exponent over the symbol for the thickness of the plate, for the pressure would vary as the square of and not directly as the thickness. As another example of loose English, this section concludes with the sentence "*All* curved surfaces not self-supporting shall be treated as *a* flat surface."

In Section 27 it is stipulated that "When stay-bolts are punched they shall be punched at least one-eighth inch less in diameter than the stay-bolt at the root of its thread." Stay-bolts are sometimes drilled, but the punching stipulation is evidently intended to apply to the plate and not to the bolt. The formula for determining the increased area of a stay which is indirectly applied, a diagonal brace, as compared with a direct or straight brace, is very badly mixed up in the reprints of the law which are distributed, but this may be due to the leaving out of subscripts on the part of the printer.

A statute which is to become a part of the written law of a state like Indiana is of sufficient importance to warrant revision and proofreading by somebody who knows the subject, before it is put on record.

*

Boiler Inspection during Construction

The closing sentence of the article "Cracked Headers on a Water-Tube Boiler," page 273, remarks the advantage of inspecting boilers while they are being built. Probably no one would dispute the statement that an inspection at that time is of more value than one made after the boiler is installed. Both are important, for a new boiler may have defects not evident before it has been in use for a season that will show up after pressure has been put upon it for a time. Quite as true is it that defects which would be almost impossible to detect after a boiler is erected would be plainly evident in a shop examination.

It may be almost too radical a proposition to put forth as a suggestion, but certainly there are attractive possibilities in the idea of a national law similar to the Food and Drugs Act, which would put the workmanship and materials used by boiler manufacturers under rigid inspection, in the interest of the public safety. The motive and the reason for such a law would be akin to those that occasioned the pure food law. Then shop inspection would not be as now, made only when the purchaser himself or his insurance company is particular enough to have it done.

This inspection service might go back farther than the boilermaker's shop and include inspection at the plate mill, even as the Government now inspects armor plate in the process of manufacture. It goes without saying that the inspectors would need to be experts by training, with actual experience in boiler and plate making, for the defects they would be expected to discover would be invisible to the eyes of a layman.

Until all states have boiler-inspection laws, such a national law as outlined, if it would not invade state's rights, would be of considerable protection. Boiler manufacturers, be they ever so desirous personally or as individual officers to avoid all chances of boiler accidents for the sake of humanity and their own good name, cannot control the conduct of their employees entirely. Wilful neglect, carelessness or ignorance on the part of an unwatched workman may easily culminate in a disaster. If outside inspection would avoid even a very few such accidents, it would be justified from every standpoint—the manufacturer's as well as the user's.

Using Examination Questions

The examination questions which appear on page 282 of this issue afford an opportunity for self-examination. Being questions actually used at Chicago in a recent test, they are thoroughly practical and should be answered in a lucid manner and not simply by reciting rules.

Probably, by much training, a parrot could be taught to repeat a formula or a rule correctly, but it would avail nothing. So with the engineer; the reasons for rules and formulas must be understood, as well as how and when to apply them before they are truly useful.

To get the real good out of answering or trying to answer these questions, the engineer must be impartial and honest with himself, answering them without help and then checking his answers by submitting them to others who are authorities or by looking up the answers in his books. Then he should mark his paper as impartially and even critically as he would were he an examiner and see how he likes the showing made.

Probably he will learn several things, among which will be that he did not have nearly the fund of information that he or his friends supposed, nor could he express creditably in writing what he did know in a general way; that the examiner was expected to know what was meant anyway, whether properly expressed or not; that the examiner actually did and generally does make liberal allowances—i.e., that the popular idea of an *upright* judge is one who *leans* considerably; that being human, he probably does lean to some extent in every case, etc. If properly conducted, such a self-examination will develop surprises and benefits unsuspected.

It is first rate to endeavor to impress others as favorably as possible, but it is best to be honest with one's self. It is told of an ancient warrior that he had for a motto on the front of his shield toward the enemy, "Be bold," but on the reverse side, for his own eyes, there were two additional words. "Be *not too* bold."

The Unusual Man

Recently an engineer traveled from Pittsburgh, Penn., to Bahia, Brazil, to do half an hour's work.

This engineer, William R. Sonricker, works for a Pittsburgh manufacturing concern that is installing some large refrigerating plants in South America, and this particular plant at Bahia would not work. Of course, the men on the construction job exhausted their resources to find and correct the defect, but they could not locate the cause of the trouble. So a cablegram was sent to the makers of the apparatus, and in response to it Sonricker was sent with all possible speed to the scene of the trouble. Upon his arrival, he located the difficulty, made the necessary adjustment and was ready to begin his return journey within half an hour.

It is fair to assume that a piece of apparatus designed for use so far away from the home shop as Bahia is from Pittsburgh would be of the simplest character possible. At least it would be designed in such a way as to avoid any complications. It is also reasonable to suppose that the men intrusted with the work of erecting the machine were familiar enough with it to correct any fault common to units of its type. The short time required by Sonricker to find the defect and apply the remedy shows that the fault was not great.

The feature of this incident which interests engineers is the reason why Sonricker was selected for this important mission to Bahia. It must have been because of his ability to find the right answer to any engineering problem that might be involved in the balk the plant had made. There were other mechanical engineers and refrigeration specialists already on the job, but they were not successful. Sonricker was peculiarly gifted as a trouble finder.

His knowledge of the machine that refused to run must be both comprehensive and microscopic; general, still specific in every detail. Not only so, but Sonricker must be more than a mere "mechanical" engineer; he must be a scientist in a sense—a close observer, an original thinker, a student of the principles and laws governing mechanical operations and apparatus, and be able to trace them with unerring accuracy back to their source and true cause. Knowledge, wide and deep, must be the equipment of the man who is intrusted with unusual missions. But further, there must be also the capacity to comprehend, to analyze, and to draw conclusions.

Men thus constituted and equipped can always command good compensation for their service, and their service is always in demand. And the best thing about it all is that the way to success in this line is no "royal road." It is open to every man on the same terms. Ambition, determination to achieve, energy, all wisely directed, constitute the terms.

Fusible Plugs

At a recent meeting of boiler inspectors, the value of fusible plugs for boilers was discussed, along with other questions. While the usefulness of the device was conceded, if kept in proper condition and frequently renewed, by most of those who discussed the question it was the opinion that fusible plugs, as used under ordinary conditions, are not reliable.

Among the rules recently issued by the Board of Boiler Rules of the State of Massachusetts the one relating to fusible plugs states that they must be filled with pure tin and that the least diameter shall not be less than one-half inch, except for working pressures over 175 lb. gage; when it is necessary to place a fusible plug in a tube, the least diameter of the fusible metal shall not be less than 3/8 in.

Thus the engineers of at least one state are required by law to use plugs of a certain fusible metal, and the minimum limit in sizes is also fixed, but nothing is found in the rules which compels a negligent engineer to renew fusible plugs at stated intervals, which would seem to be one of the main precautions to guard against their failure.

If the fusible metal always remained clean and free from coating, the necessity of frequent renewal would be eliminated, but with the ordinary feed water, deposits adhere to the surface of the plug, and in many instances have effectually prevented it from fusing.

If a fusible plug is not filled with the proper fusing metal, and if it is not kept clean, it becomes a menace and fails as a safeguard.

Engineers have an opportunity to note the action of safety plugs in their boilers, and undoubtedly have formed an opinion as to their value as a safety appliance. Are they or are they not to be depended upon?

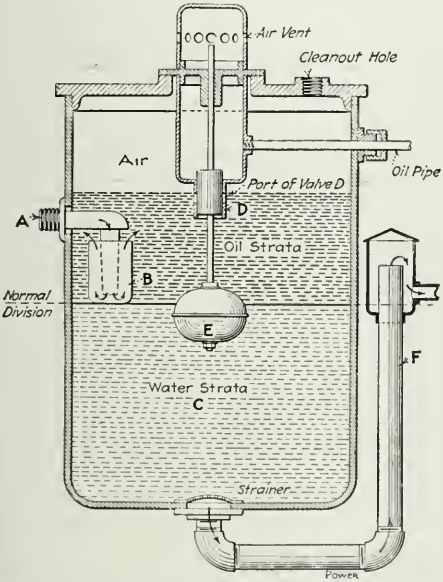
Correspondence

Gravity Oil Separator

On page 862, June 16, J. M. Long describes a float of the balanced differential type. It brings to my mind a piece of apparatus I built some years ago for separating oil and water.

It will automatically separate oil, air and water—in fact, anything which does not mix chemically and in which there is sufficient difference in the specific gravity to operate a float.

The condensate enters at *A* and is directed upward and into the strata of oil by the pipe *B*. The tank *C* is fitted with a float *E* and piston valve *D*, shown in a closed position. The float is so balanced that it will sink in oil and float in water, thus opening and closing the valve *D* to the atmosphere and the oil-vent pipe.



Section of Filter

The tank *C* contains a certain amount of oil and water, and an increase of either will change the position of the float and cause the separator to act.

For instance, an increase in the water in the tank *C*, and column *F*, will cause it to overflow from *F* so long as it is supplied at *A*. With oil accumulating in tank *C*, thereby gradually lowering the level of the water, the float will operate the valve *D*, thereby allowing a small amount of oil to escape and to balance the machine again.

If any great amount of air is taken in at *A*, the operation would be practically the same. The levels would lower, due to the air volume above the oil increasing, and continue to lower until the valve *D* opened, and the air would escape.

No filters are used and the water is clean, due to the condensate entering the oil strata first and then falling by gravity, leaving the air and oil at the upper part of the apparatus.

Edward O. Johnson.

East Orange, N. J.

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Boiler Capacity and CO_2

Relative to the inquiry of J. M. on page 145 of the July 28 issue, there will be no decrease in the capacity nor pressure of the boilers by slowing down the fan, providing the low percentage of CO_2 is due to too much air being forced through the fuel. The furnace temperature will be increased as there will be the same number of heat units contained in the lesser amount of furnace gas and hence more water will be evaporated. There is a definite relation between the amount of draft and the thickness or resistance of the fire. The thickness of the fire depends upon the character of the fuel and the size of the grate surface in relation to the capacity of the boiler; and the draft can be decreased to the proper minimum of excess air with an increase in economy.

If, however, the low percentage of CO_2 is due to air leaks in the setting or holes in the fuel bed, the CO_2 can be increased very little by reducing the draft and any attempt to reach a good percentage of CO_2 by this method will result in a decreased capacity and a drop of pressure; for when the draft has been regulated so as to burn the fuel with the minimum of excess air, the products of combustion being mixed with additional air above the grates, any further decrease in draft will result in incomplete combustion and the forming of CO instead of CO_2.

C. Leslie Barnum.

New Brighton, N. Y.

I find the altogether too general belief that a test for CO_2 is a test of flue gases. Undoubtedly a CO_2 test is better than none, but it does not tell the whole story. High CO_2 is taken to mean good combustion and low CO_2 bad. But of what value is high CO_2, if in getting it the draft is reduced to a point where CO passes up the stack unburned. Why not test for oxygen, CO_2 and CO, which would really amount to something.

The most economical point at which a boiler will work is usually not that at which it will evaporate the greatest amount of water; that is, by slowing down the fan, greater economy may be attained, but less coal can be burned.

Whether the boiler in this particular case would evaporate more water after slowing the fan is a question one can only attempt to answer from experience. I have tested boilers that developed 160 per cent. rating and the flue gases showed as low as 9 per cent. CO_2, and a high percentage of oxygen with no CO. Upon taking off the blower the steam pressure dropped to 90 per cent. with practically no oxygen and 3 per cent. CO. If anything like this happens when the fan is slowed down the pressure will drop, but with a slight reduction of air, better conditions and greater evaporation will result.

J. A. Coltrin.

Kewanee, Ill.

Flue-gas analysis alone is no gage of furnace efficiency. If 5 to 8 per cent. CO_2 is found on analysis of the flue gases, it may be due to a clinkered fire, too much draft with a thin fire, a fuel bed full of holes, or possibly air leakage through the setting. These causes for excess air must be detected, one by one, with the Orsat and draft gage. Then the draft necessary for various thicknesses of the fuel bed to obtain good combustion can be determined. The meager information given in the question will not enable one to determine whether the boilers will steam better or hold the required pressure.

H. A. Cox.

Middletown, N. Y.

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Patching Boilers

In reply to J. C. Hawkins' letter on page 25, July 7, I desire to say that the Hartford Steam Boiler Inspection & Insurance Co. had an article on that subject in its *Locomotive*, July, 1897, on page 97, and a more extensive article, July, 1908. The forms of patches are analyzed in those articles, and the form spoken of has been recommended by Hartford inspectors for some twenty years.

Thomas E. Shears.

Denver, Colo.

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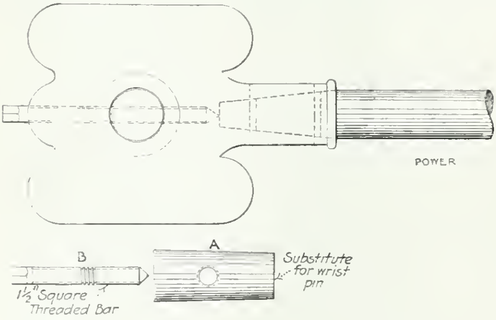
Getting a Crosshead Off

Noting A. C. Waldron's method of removing the crosshead from the piston of large engines, on page 103, July 21, I think the following method is infinitely easier and more simple:



A Jack for Crossheads

A pin *A* slightly smaller than the wristpin is drilled and tapped at right angles to its length to receive a 1½- or 2-in. bar or screw *B*, which is threaded and one end pointed to fit into the center in the piston rod, while the other end is squared for a wrench.

Insert pin *A* in the crosshead in place of the wristpin. Screw bar *B* into it until it engages the center in the end of the piston rod. Screw it up snug, tapping the crosshead lightly with a soft hammer at the same time, and the rod will yield readily.

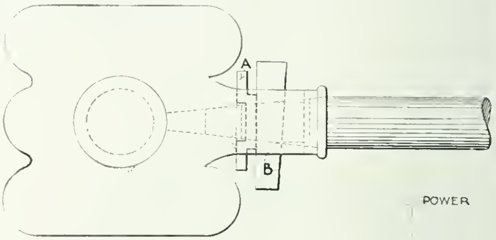
The size and length of the bar *B* is, of course, determined by the size and type of the engine. Obviously, the shorter it can be made, the better.

George G. Lee.

Ottawa, Ont., Canada.

With the larger sizes of engines having taper-fitted rods, the manufacturer formerly furnished a "drifting" set for removing the rod from the crosshead.

The illustration will interest any who may not have seen one. After removing the key, the offset piece *A* is inserted into the slot against the crosshead at the end next to the crank; a small piece, which is a little shorter than the rod's diameter, is used in the other end of the slot against the rod. By driving the key, the most stubborn set is loosened.

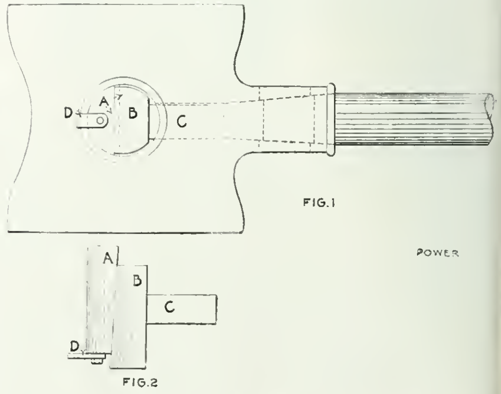


Drifting Set to Remove Crosshead

John F. Hurst.

Louisville, Ky.

Another method of removing a crosshead from a tapered piston rod is shown in the illustration. Part *A* is made tapered and is circular in shape on one side, to fit the eye, and flat on the other side. Part *B* is smaller than the eye, and is also tapered, but is flat on opposite sides, forming a wedge. *B* is a mandrel of the right length to make up the distance between the end of the



Wedges for Removing Crosshead

piston rod and the wedge *B*. Stop *D* is to keep *A* from driving out. With the members assembled as shown, it is evident that a blow on wedge *B* will start the piston rod from the crosshead.

J. A. Lucas.

New York City.

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Care of Commutators

I have not been bothered with commutator trouble for two years. Before that it was necessary to turn down the commutators every two or three months. They would run all right for a few weeks after turning, and then begin to heat again. I was in the habit of wiping them two or three times a day with engine oil, thinking that this was the proper thing. However, a light, slender carbon streak would begin to form at equal distances on three sides of the commutators on both of our 120-volt generators. From the width of a pencil, these grew little by little, until the whole commutator was black in five or six weeks.

These spots were sandpapered occasionally, and the black deposit wiped off to an appreciable extent, but always there remained the microscopic pitting on the surface of the bars, and three to four hours later it would be hot.

I usually repeated the process with as much diligence as possible, endeavoring for an effective cure, but the only way was to keep running until Saturday noon, when the repair squad would take the commutators over to the machine shop to be turned. A remedy has now been found in the following treatment:

Melt common wax in a pan, and put into this as much graphite as it will hold; leave it to cool and then cut it into cakes of about a cubic inch. The wax holds the graphite together. If the commutator heats, sandpaper it thoroughly; then apply this home-made cake. It will readily melt when held on the hot commutator. Come back several minutes after and touch it up again. Never use oil. If the commutator has a chocolate surface, it may not be necessary to sandpaper it, and the graphite composition may suffice.

Luke Marier.

Fall River, Mass.

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Consulting Engineering Gratis

The editorial on this subject in the July 7 issue reminds me of a few instances when I was called on for help.

In one case a coal company had a 150-kw. generator driven by a simple engine which had operated satisfactorily for two years, but finally developed a serious knock. Upon arriving at the plant I was met by the superintendent, bookkeeper, store manager and many miners. All seemed to think the engine was "done" and ready for the scrap pile. After getting all the information I could it seemed to me that the trouble must be in the cylinder. I found that the follower had been bumping the head; one turn of the rod remedied the trouble. I received for my pay a kind "thank you ever so much until you are better paid."

On another occasion a mining company was notified that the air inspector would arrive, and as the air conditions were bad, the company attempted to improve matters by installing a small fan at one of the air courses, driving it with an old motor from the scrap pile. After all was apparently ready for the trial, the current was turned on; instead of the motor starting, the resistance in the starting box burned out. This happened twice, and then I was sent for.

I told the manager it would be impossible for me to leave my own plant at that time, but if necessary I would come after I got off duty. He insisted on it, and after riding a wheel six miles I arrived at the mines. The trouble was found and remedied quickly.

With a smile on his face, the manager stepped to one side out of the draft of the fan, took from his vest pocket a cigar, of which he had a good supply, lit it—and kept the rest in his pocket. After satisfying himself that all was ready for the air inspector, and without asking me if I had made arrangements for staying over until morning, or even finding a place for me to sleep, he turned in the direction of his bungalow and soon disappeared in the darkness.

Such experiences have taught me how to deal with people who want help. Now, when I am called for in an emergency, there is always an understanding at the start as to whether it is for business, pastime or for "In God we trust."

W. H. Corbin.

Sharples, W. Va.

⁂

Fastening Ball on Rod End

The thread was stripped from a Buckeye valve-gear and the ball on the end of the cutoff valve rod came off. The rod end did not go through the ball, so I filed the shoulder back for an eighth of an inch, so that the rod would extend through; put the ball on and riveted the rod end until the ball was fast; it has never come loose since. The valve was easily adjusted by shortening the eccentric rod.

Herbert Holroyd.

Philadelphia, Penn.

⁂

Hot Motor Bearings

One of the bearings on a 30-hp. motor always became very warm during a day's run, but no reason could be found for this as there always was plenty of oil in the oil well; moreover, it was renewed often. The bearings were of ring-oiled type. One day the bearing became warmer than usual and an investigation showed that the oil ring was not turning. The bearing was then taken apart and it was found that the inside of the oil ring, where it comes in contact with the shaft, was very smooth due to wear from long use. This made it impossible for the ring to turn with the shaft. By roughing the inside of the ring with a coarse file the trouble was cured.

I believe this bearing always ran warm because the oil ring did not turn at times so as to bring oil on top of the shaft, when the bearing would run dry. Again the oil ring would get into a position so that it would turn for a short time, then stop again. This same trouble will also occur where the inside of the ring has worn out of round from long use, when it will not turn freely with the shaft at times and must be started again by means of a stick through the oil-well hole.

In another instance, two bearings of the single-ring-oiler type on a large motor ran hot. Upon investigating, it was found that the rings did not turn at all and could not be made to turn with a stick through the oil-well cover. The bearings were then taken apart and it was found that the oil was of a sticky nature. Upon inquiring of the operator as to what oil he used, it developed that it had been taken out of a ten-gallon oil can standing near the motor. This was found to contain steel-cable dressing. Due to the bearings being hot. the oil rings were baked to the sides of the slot in the top bearing.

H. A. Jahnke.

Milwaukee, Wis.

⁂

Examination Questions

The accompanying questions were asked in an examination held June 13, 1914, for the position of engineer-custodian, class E, group D, Board of Education, Chicago, Ill. Some people used to think that school engineers were janitors and scrubwomen, but the standard is improving, due to efforts to bring into the service the best class of engineers. The method pursued is a good one.

In the past, the examinations have been so easy that from 50 to 75 per cent. would pass, but I dare say that in this examination only about 10 per cent. of the 300 applicants will attain the eligible register. These high requirements will bring into the service men who have thorough engineering knowledge, though not necessarily a college education:

Questions

1. Name and discuss fully three ways in which the formation of scale in boilers is detrimental to the economical operation of a steam plant.

2. A certain boiler evaporates 3000 lb. of water per hr. at atmospheric pressure from a feed-water temperature of 160 deg. F., burning 500 lb. of coal in the furnace. If the coal is 80 per cent. combustible, what is the equivalent evaporation from and at 212 deg, per pound of combustible?

3. In example (2) above, (a) what was the boiler horsepower developed, and (b) if the coal used contained 12,100 B.t.u., what was the combined efficiency of boiler and furnace?

4. The shell of a tubular boiler 60 in. in diameter by 16 ft. long is $\frac{5}{16}$ in. thick; efficiency of joint, 81 per cent.; tensile strength of steel, 60,000 lb. per sq.in. Assume what you would consider the proper factor of safety and calculate the safe working pressure on this boiler and the proper size of lever safety valve for use at the calculated pressure.

5. A simple engine running 180 r.p.m. has a piston 10-in. diameter by 12-in. stroke; piston rod 1½ in. in diameter; m.e.p. 35 lb. per sq.in. If the mechanical efficiency of the engine is 90 per cent., what brake horsepower is the engine developing?

6. Define the meaning of the terms watt, ampere, volt, kilowatt. What is meant by a ground, on an electric-lighting system? What is the gage of the smallest wire that can be used in an interior electric-lighting system? What is the maximum load in watts that should be put on one electric-lighting circuit? How many horsepower are equivalent to one kilowatt?

7. (a) What is the difference between a simple and duplex steam pump, and name the relative advantages of each? (b) How many strokes of a simple pump with piston 5-in. diameter by 10-in. stroke will it require to fill a circular tank 4 ft. in diameter by 12 ft. high, allowing 20 per cent. for slippage?

8. (a) How many pounds of steam at atmospheric pressure will be condensed in a cast-iron indirect radiator in heating 25,000 cu.ft. of air from 15 deg. to 120 deg. F.? (b) Define "relative humidity." How is relative humidity affected by increase in temperature? What is meant by "dew point?"

9. A classroom contains 48 pupils. How many cubic feet of fresh air should be delivered to this room per hour to provide proper ventilation? What is the maximum velocity and maximum temperature at which air should enter the classroom through registers? What is the maximum percentage of CO_2 permissible in the atmosphere of a classroom?

10. Between what temperature limits should a classroom be kept? How long before opening for the school session should the classroom temperature be up to requirements?

11. Describe fully the construction of some type of thermostat with which you are familiar and which operates by means of compressed air, and describe how the thermostatic system in a school building automatically maintains the classroom temperature within the prescribed limits, when the plenum, single-duct blast system is used for heating and ventilating. Illustrate.

Arithmetic

1. (a) Multiply $15\,{}^1/_2$ by $6\,{}^3/_8$.
   (b) Divide 101.6688 by 2.36.

2. Compute the total pressure and pounds per square inch on the bottom of a cylindrical vessel 6 in. in diameter by 3 ft. high filled with a liquid which weighs 56 lb. per sq.ft.

3. The specific heat of cast iron is 0.13. How many heat units will a bar of cast iron weighing 30 lb. give up in cooling from 850 deg. to 60 deg. F.?

4. One cubic foot of steam at 70-lb. pressure weighs 0.195 lb. Allowing a steam velocity of 5000 ft. per min., what diameter of pipe will be required to supply 6500 lb. of steam per hour at a gage pressure of 70 lb. per sq.in.?

5. If the coefficient of friction is 23, how many horsepower will be required to draw a weight 3600 lb. up an incline at the rate of 55 ft. per min., if the incline rises 1 in. per ft.?

Report

Assume that you were in charge of a steam-heating plant consisting of three tubular boilers such as are used in school buildings, and it was found that you were burning too much coal. Write a report explaining how you would proceed to investigate the cause of the excessive coal consumption. Confine your investigation to the boiler room. Write a report of 150 words.

Experience

What experience have you had as an operating engineer?

What experience have you had in the following lines? (a) Plumbing. (b) Steam fitting. (c) Electric work.

A. E. Christophersen.

Chicago, Ill.

Inquiries of General Interest

Allowance for Frictional Resistance of Boiler Plates—In calculating the resistance of riveted joints of boilers, why is not the resistance of friction between the plates taken into consideration?

L. M.

The resistance due to friction between the plates may vary from 0 to a small percentage of the shearing strength of the rivets and no allowance can be made for such resistance because of its uncertainty.

Vent and Waste Trap on Open Heater—What is the purpose of a vent or vapor pipe, and also of an S-trap, on an open heater?

F. B.

A vent pipe connecting with the atmosphere is used to prevent the steam space from becoming air bound and also to prevent formation of a vacuum, which would endanger the shell of the heater to the collapsing pressure of the atmosphere. A running or "S" form of waste trap is used on the overflow to prevent steam from escaping to the sewer or other point of discharge of the overflow.

Siphonage Between Connected Boilers—When two boilers having their water lines at different levels are connected into the same steam line, is there any tendency for water to be siphoned over from one boiler to the other?

A. F. L.

With ordinary boiler connections there would be no siphonage of water from one boiler to the other, but if the feed connections of the boilers are connected together and the check valve of the boiler of higher water level leaks, then water would back up from the boiler of higher water level to that of lower water level.

Renewing Firebrick Lining—In putting an entirely new lining of firebrick under a horizontal-tubular boiler which is supported by brackets resting on the side walls, is it advisable to rebuild the side walls?

W. N. J.

The necessity for renewing the side walls would depend upon their condition and the manner in which they have been incorporated with the lining. Ordinarily side walls are built to support the boiler independently of the firebrick lining and the lining may be renewed without impairing the safety of the side walls.

Superiority of Flanged Over Screwed Fittings—In steam mains what are the advantages of flanged elbows and tees over screwed fittings?

C. J.

Besides the greater facility with which flanged joints may be made up or detached the fittings are not subjected to the bursting strain of making up tapered screw joints, which in screwed fittings are likely to be set up so hard as to leave little or no strength to resist a bursting pressure or to resist such stresses of leverage as are exerted on the fitting by expansion and contraction of different parts of the line.

Formula for V-Notch Weir—When the head is measured in inches, what is the formula for flow of water in cubic feet per minute over a right-angle V-notch weir?

J. R. P.

The formula is:

$$Q = h^2 \times \sqrt{h} \times 0.305$$

where

h = The head in inches measured vertically from the still water above the weir to the vertex of the notch;

and

Q = The number of cubic feet flowing per minute.

Formula for Weight of Flywheel—What is the formula for the weight of the rims of flywheels for Corliss engines?

F. W. A.

Where 480 ft. per min. is the lowest probable piston speed the weight for the rims of flywheels of Corliss engines of ordinary duty is given by the empirical formula:

$$W = 700{,}000\ d^2\ s \div D^2\ R^2,$$

in which

W = Weight of rim in pounds;
d = Diameter of cylinder in inches;
s = Stroke in inches;
D = Diameter of wheel in feet;
R = Revolutions per minute.

Flow Through Gate Valve—How can the amount of condensing water which is being discharged through a gate valve be determined from the number of turns of the handwheel?

C. A. H.

On account of the uncertainty of the amount of opening and variable coefficient of discharge for different openings, the discharge capacity of the valve should be calibrated by tank or weir measurements for different positions of the valve and for the different pressures employed on each side of the valve. The results of such a calibration can be arranged in the form of a table or chart by reference to which the discharge taking place under a given set of conditions could be readily determined.

Atmospheric Pressure at Bottom of a Shaft—What would be the pressure of the atmosphere at the bottom of a shaft which is sunk from sea level to a depth of 1000 ft.?

W. A. D.

The pressure of the atmosphere increases with the depth of shafts equal to about 1 in. rise in the barometer for each 900 ft. increase in depth. Assuming the pressure of the atmosphere at the top of the shaft to be 14.7 lb. per sq.in., then as 1 in. rise in the barometer would be equivalent to an increase of 0.491 lb. per sq.in., the pressure at a depth of 1000 ft. would be

$$14.7 + \left[\frac{1000}{900} \times 0.491 \right] = 15.246, \text{ or about } 15\tfrac{1}{4} \text{ lb. per sq.in.}$$

Power Required for Centrifugal Pump—What horsepower would be required of a motor to drive a centrifugal pump which has a rated capacity of 260 gal. of water per minute discharging against a total head of 120 ft. with an efficiency of 52 per cent.?

S. B. R.

Taking the weight of 1 gal. of water as 8⅓ lb. then to discharge 260 gal. per minute against a head of 120 ft. with an efficiency of 52 per cent. would require

$$\frac{260 \times 8\tfrac{1}{3} \times 120}{0.52} = 500{,}000 \text{ ft.-lb. of work per minute.}$$

Hence the power developed by the motor would have to be 500,000 ÷ 33,000, or 15.15 hp.

Pipe Bending—How can pipes be bent without caving or flattening them?

J. G. M.

The commonest method of preventing flattening or caving from bending is to first fill the pipe with sand or pulverized rosin firmly tamped and held in place with a plug at each end of the pipe Caving-in occurs from too much concentration of bending force, hence any method of bending should be performed by a succession of grips taken close together. The smaller sizes of steel and iron pipe can be bent cold to quite a small radius of curvature and without first filling them by taking a sufficiently large number of short grips and using a cover pipe or a stiff mandrel within the pipe to prevent the occurrence of bends too far from the grips. Short bends of uniform curvature are made by passing the pipe between rolls grooved on their periphery to fit nearly half way around the pipe, employing two rollers on the outside and one on the inside of the curvature of the bend in the same way that three rolls are used for curving a boiler sheet. Another method of bending largely used for smaller sizes of pipe, and pipe of softer materials, is by bending or "wiping" the pipe over forms that will give the desired curvature.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXIII

Last Lesson's Answers

101. The three factors that determine the quantity of heat in a body are (a) the specific heat of the body. (Note: *the specific heat of a body is the amount of heat required to raise one pound of the substance one degree Fahrenheit*); (b) the weight of the body and (c) the range of temperature above a given reference point. As an example find the amount of heat in one hundred pounds of water above 32 deg. F. if the temperature of the water is 62 deg. F. The specific heat of water is unity—the weight is 100 lb.—and the range of temperature above 32 deg. F. is 62 — 32 = 30 deg.; hence the total heat in the water above 32 deg. F. is 1 × 100 × 30 = 3000 B.t.u.

As a general rule the heat in a body is measured with reference to the temperature at which the body changes from a solid to a liquid, or a gas.

102. *Temperature expresses the degree or intensity of the heat in a body* and is measured by the rise of a column of mercury placed in a glass tube of fine uniform bore. On the Fahrenheit scale the freezing point of water is located at 32 deg. and the boiling point at 212 deg. Between the freezing and boiling points there are 180 divisions (212 — 180) on the scale. Hence, a change of one degree Fahrenheit means that the mercury rises a distance equal to $^1/_{180}$ of the distance between the freezing and the boiling points.

103. The quantity of heat required to change the temperature of one pound of water one degree Fahrenheit decreases as the temperature of the water increases. This is due to the fact that the density of the water decreases with an increase of temperature.

104. The total heat liberated per hour by the complete combustion of 1000 lb. of the fuel is

$$12{,}000 \times 1000 = 12{,}000{,}000 \text{ B.t.u.}$$

and the heat liberated per minute

$$\frac{12{,}000{,}000}{60} = 200{,}000 \textit{ B.t.u.}$$

As one horsepower equals 42.3 B.t.u., the horsepower equivalent to the heat set free is

$$\frac{200{,}000}{42.3} = 4728 \textit{ hp.}$$

The equivalent boiler-horsepower is

$$\frac{4728}{13} = 363 \textit{ boiler hp.}$$

Under actual working conditions, only about 80 per cent. of the above figure could be secured, assuming that a water-tube boiler was used, so that the probable boiler-horsepower would be about

$$0.8 \times 363 = 290 \textit{ boiler-hp.}$$

105. From the conditions of the problem the heat absorbed by the water equals 0.80 × 12,000,000 or 9,600,000 B.t.u. per hour. To evaporate one pound of water requires 1050 B.t.u., hence 9,600,000 B.t.u. will evaporate

$$\frac{9{,}600{,}000}{1050} = 9143 \textit{ lb}$$

Under working conditions, approximately 30 lb. of water must be evaporated to produce a boiler-horsepower, hence the boiler-horsepower is

$$\frac{9143}{30} = 304 \textit{ b.hp.}$$

which agrees very closely with the answer given in problem 104.

The Inclined Plane

In Lesson XII, the term "machine" was defined and several types were discussed. Some additional forms will now be discussed with relation to the work done by the machine.

Frequently, in construction work, heavy objects such as parts of machines, etc., must be lifted when, with the apparatus available, it is impracticable to raise the object directly. In such instances, the *inclined plane* is used. A common application of it is in the loading or unloading of heavy machinery from freight cars. A long incline is built in front of the car and the piece of machinery placed upon a skid which in turn rests upon the inclined plane. By the aid of the proper tackle the part can be drawn up to the car.

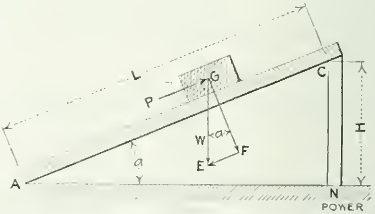


Fig. 69.

In the following discussion two general cases will be considered:

(1) The plane perfectly smooth—thus eliminating friction.

(2) The plane rough—thus including friction.

Case I. Smooth Plane—Friction Neglected

Let AC, Fig. 69, represent the given plane inclined at an angle of a degrees with the horizontal and assume the body G to be acted upon by a force P parallel to the plane. The weight W may be resolved into two components—one parallel to the plane and the other at right angles to the plane. Since in this case friction is to be neglected, the only force tending to oppose the force P will be the component EF of the weight W down the plane. By construction, the angle EGF = the angle CAN = the angle a. The component $EF = W \times \sin a$, hence the force P must equal the component EF or $P = W \times \sin a$.

Let H = the height of the plane, and L = the length of the plane. Since $\sin a = \frac{CN}{AC} = \frac{H}{L}$ it follows that

$$P = W \times sin\ a = \frac{W \times H}{L} \qquad (59)$$

Example—What force P will be required to move 1000 lb. on a plane which rises 1 foot in 10. Here the

$$sin\ a = \frac{H}{L} = \frac{1}{10}$$

and the force

$$P = \frac{W \times H}{L} = \frac{1000 \times 1}{10} = 100\ lb.$$

This shows that a force of 100 lb. acting parallel to the plane is capable of moving 1000 lb. up the plane.

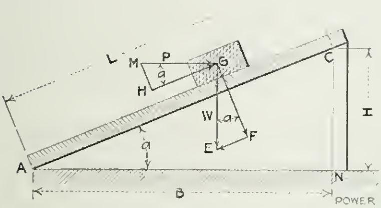


FIG. 70.

Fig. 70 shows a case where the force P is horizontal instead of being parallel to the plane. Here the only effective force tending to move the body up the plane will be the component of the force P parallel to the plane. By construction, it is readily seen that the angle HGM is equal to the angle CAN = the angle a. The component of the force P parallel to the plane = $GH = MG\ cos\ a = P\ cos\ a$. The force acting down the plane is, as before

$$W \times sin\ a$$

For equilibrium to exist, the forces acting up the plane must equal the forces acting down the plane or

$$P\ cos\ a = W\ sin\ a \text{ or,}$$

$$P = W \frac{sin\ a}{cos\ a} = W\ tan\ a \qquad (60)$$

Let B = the length of the base of the plane. Then,

since $$sin\ a = \frac{CN}{AC} = \frac{H}{L}$$

and $$cos\ a = \frac{AN}{AC} = \frac{B}{L}$$

it follows that $$P = W \frac{sin\ a}{cos\ a} = W \frac{HL}{LB} \text{ or}$$

$$P = W \frac{H}{B} \qquad (61)$$

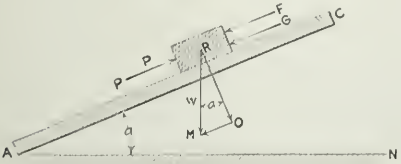


FIG. 71.

Example—What force P will be required to move 1000 lb. up a plane whose base angle is 5 deg. 50 min.? From equation (60)

$$P = W\ tan\ a = 1000\ tan\ 5\ deg.\ 50\ min. = 1000 \times 0.102 = 102\ lb.$$

This demonstrates that the horizontal force required to move the body up the plane is greater than the force parallel to the plane.

CASE II—PLANE ROUGH—FRICTION INCLUDED

When a body is on the point of moving up the plane, both the force of gravity and the force of friction tend to oppose the motion, as both these forces are acting down the plane. On the other hand, if the body is on the point of moving down the plane the force of gravity will tend to help this motion, but the force of friction will act up the plane as *friction always acts opposite to the direction of motion.* Hence between certain limits the body will remain at rest on the plane.

In Fig. 71, let the force P act parallel to and up the plane. Then the force of friction F down the plane will equal the coefficient of friction f times the normal reaction RO (see lesson XIV), and the force of gravity G, acting down the plane is equal to $W\ sin\ a$. For equilibrium to exist $P = F + G$,

but $$F = f \times RO = f \times W\ cos\ a, \quad \text{therefore,}$$

$$P = fW\ cos\ a + W\ sin\ a \qquad (62)$$

The force P required to put the body in motion up the plane will be greater than that given by equation (62) by an amount equal to the force required to overcome the inertia of the body. When the force P has the value given in equation (62), the body will just be on the point of starting up the plane.

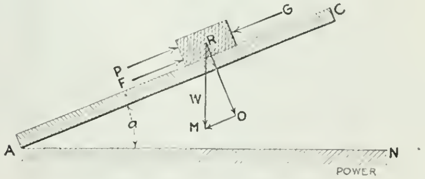


FIG. 72.

In Fig. 72, let the force P act up the plane and assume the body to be on the point of moving down the plane. In this case for equilibrium to exist, the force of gravity acting down the plane must be balanced by the force of friction and the force P acting up the plane or

$$G = P + F, \text{ or } P = G - F$$

but $$F = f \times W\ cos\ a$$

and $$G = W\ sin\ a, \quad \text{therefore,}$$

$$P = W\ sin\ a - f\ W\ cos\ a \qquad (63)$$

For the body to remain at rest on the plane, the value of the force P must lie between the limits of $W\ (f\ cos\ a + sin\ a)$ and $W\ (sin\ a - f\ cos\ a)$.

STUDY QUESTIONS

106. In Fig. 69, what force P will be required to hold a skid carrying a steam pump at rest on the plane AC? Neglect the force of friction. The plane rises 1 in 12 and the weight of the skid and pump is 1600 lb.

107. With the same data as given in 106, find the horizontal force P required to hold the skid on the plane.

108. If the coefficient of friction between the skid and the plane is 0.18, find the least force P which will prevent the skid from sliding down the plane.

109. Find the force P parallel to the plane which will just start motion of the skid up the plane. Assume the same data as in the previous problem.

110. Under what conditions will it be necessary for the force P to act down the plane to set the body in motion. See Fig. 72.

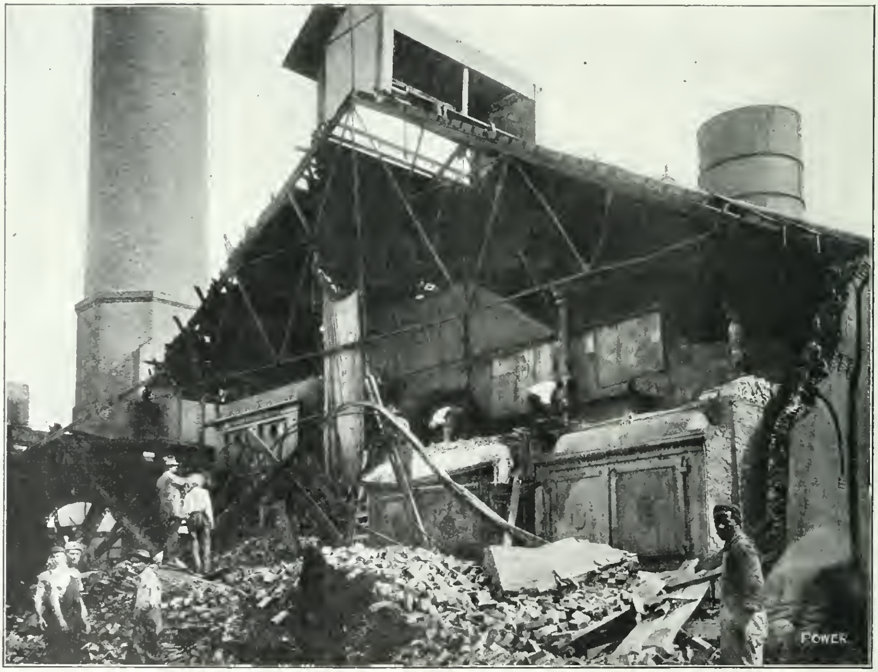
Cast-Iron Boiler Explodes

On the evening of July 10, a cast-iron boiler exploded in the Langston & Son machine shop, at Camden, N. J. It appears that steam from this boiler was used during that day to test some brass cylinders.

At the time the boiler failed the pressure was 30 lb. and the pop safety valve inactive. Fortunately the watchman had just left the room, and no one was injured, although the boiler was completely wrecked and several windows and doors broken. Who removed the safety from the safety valve? Another call for inspection and competent supervision over boilers of all classes by the state.

Cyclone Wrecks Henderson, Ky., Plant

A cyclone damaged the municipal electric-light plant at Henderson, Ky., July 16. Herewith is a view of the wrecked boiler room which was cut in half. The falling bricks, steel and timbers stripped the fronts of the boilers of all the small pipes, water-gage columns and steam gages.



Cyclone-Wrecked Plant at Henderson, Ky.

The two 400-hp. Atlas boilers, on the right, were in service at the time, and the 400-hp. Stirling boiler, on the left, is a new one being erected. If the cyclone had occurred 30 minutes sooner it is likely it would have caught about 15 men at work on the installation of the new boiler; they had just quit and left the boiler room. The one fireman in the boiler room at the time had just stepped in between the Atlas boilers to regulate the feed water when the roof came in on him, but he climbed out uninjured over about 8 ft. of wreckage.

The accident happened about 6 p.m., and as it continued to rain and blow quite hard for the rest of the night the repair work was not started until the next morning. The traction cars and interurban lines were in operation about five o'clock that afternoon and the city service in the business part was put on at 7 p.m. next day, being out about 25 hours.

The new 225x11-ft. brick chimney, just recently built, escaped injury. The boiler room will be rebuilt with a steel-frame construction and enlarged to a sufficient size to accommodate five 400-hp. boilers. A great many wires were down all over town on account of trees blowing down on them, but only a few poles were broken.

We are indebted to L. P. Hite, the superintendent of the plant for the above information.

Program for World's First International Engineering Congress

The Panama-Pacific International Exposition, San Francisco, from Sept. 20-25, 1915, will be the meeting-place of the largest body of distinguished engineers that ever gathered in any one place. The assemblage, to be known as the International Engineering Congress, will be presided over by Col. George W. Goethals, who has accepted the office of honorary president.

In response to over 80,000 invitations, thousands of civil, mining, mechanical, electrical, marine and military engineers and naval architects, from nearly forty different nations and representing hundreds of affiliated bodies, have declared their intention of attending the congress. The sessions will be held in the new million-dollar Auditorium now being constructed in the civic center of San Francisco, the main hall of which has a seating capacity of ten thousand. Section meetings will be held in the eleven minor halls in the great convention building.

The International Engineering Congress is to be conducted under the auspices of five national associations, viz., the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers, assisted by a committee of eighteen distinguished California engineers.

The vast scope of the congress is indicated by the fact that it will be divided into eleven groups of sub-congresses, the reports of which it is calculated will fill eleven large volumes. Chief among these branches will be that dealing exhaustively with the problem worked out in the construction of the big Isthmian ditch, and the influence of the canal on world commerce, commercial trade routes and general transportation problems. Colonel Goethals will have charge of the presentation of all canal topics, and his papers and discussion will carry with them the authority and value of official reports. Aside from general engineering topics, the section devoted to the canal will be treated under 22 heads, as follows:

(1) Col. Goethals' general report; (2) Dry excavation of the Panama Canal, by Col. Goethals; (3) Dredging the canal (4) Terminal works, dry docks and wharves of the canal; (5) Meteorology and hydrology of the zone; (8) Designs of locks, dams and regulating works; (9) Methods of construction of same on the Atlantic side; (10) Same on the Pacific side; (11) Designs of locks, walls and valves; (12) Spillways; (13) Gates of the canal; (14) Electrical and mechanical installation; (15) Emergency dams above locks; (16) Municipal engineering and domestic water supply in the zone; (17) Reconstruction of the Panama Railroad; (18) Aids to navigation of the canal; (19) Geology of the canal zone; (20) The working force of the canal; (21) Sanitation in the zone; (22) Purchase of supplies for the canal.

Following Colonel Goethals' personal reports, each of these topics will be treated by the heads of departments or other attachés who were responsible for that part of the canal construction. These addresses and papers will constitute practically the official technical record of the most gigantic and fascinating engineering feat of all time. It will be published, forming the only printed record of its kind, and for this compilation, interesting to the layman no less than to engineers, credit is due to the exposition congress. Programs for the other ten sections of the congress are in course of preparation.

Subscriptions are being received daily by the local organizations which will act as hosts for this great body, a large proportion of these being from foreign bodies and foreign engineers. The most noted experts of the world in all departments of engineering work have availed themselves of this opportunity not only to visit the exposition, but to pass through the canal en route.

* * *

Marion Station Coal-Crane Wreck

A high wind blew down the 150-ton gantry crane at the Marion power station of the Public Service Electric Co. of New Jersey, on July 23. The crane, which was parallel with the station, was blown along its track for a distance of about 300 ft., falling over on a yard locomotive. Eight wheels on one side were locked by brakes. When the storm broke, the crane was standing at the western end of the track on a coal dock on the Hackensack River. The wind started the crane, which acquired a high rate of speed along the level track, falling at the opposite end of the track. The tracks upon which the locomotive was standing were pushed about 2 ft. into the ground.

The crane had been in service 10 years. It handled coal from barges to storage piles and from the piles to the hoppers in the buildings.

The wreck of the crane is shown in the accompanying views. The span of the crane was 150 ft. 2¼ in., the height 43 ft. 1 in. to the upper chord, and the wheel base 27 ft. long. The principal operating features of the crane are shown in Fig. 1 of the tower nearer the station.

The cross structure of the crane carries a belt, which can be supplied with coal from the belt conveyor running parallel with the station. The coal is conveyed on the crane belt to about the center where it is tipped, falling to storage piles. When it is desired to return the coal from the piles to the station, the clam-shell bucket places the coal in the hopper over which it is suspended (Fig. 1). After being crushed it is carried up to the belt on the stationary structure, running parallel to the travel of the crane. The track on which the crane travels is 300 ft. long and is not provided with bumpers at the end.

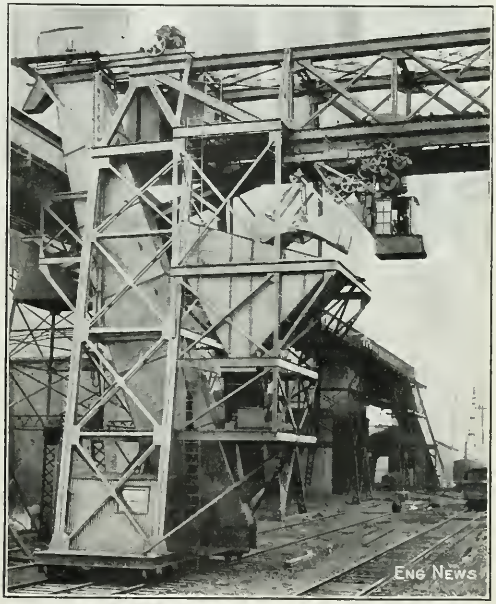


Fig. 1. One End of Crane before Accident

The high wind carried the crane from one end of its track to the other, and when the crane reached the end of the track, the forward trucks went off to the ground, a distance of about 8 ft., where they sank. The crane, of course, fell over in the direction of its motion,

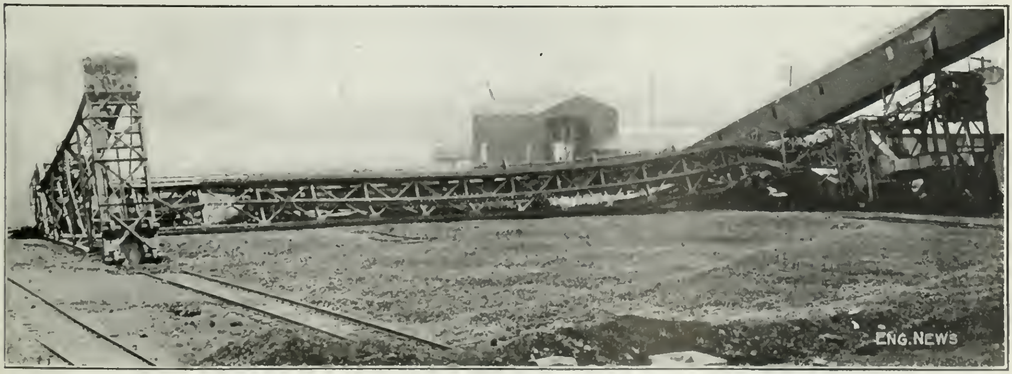


Fig. 2. General View of Overturned Crane

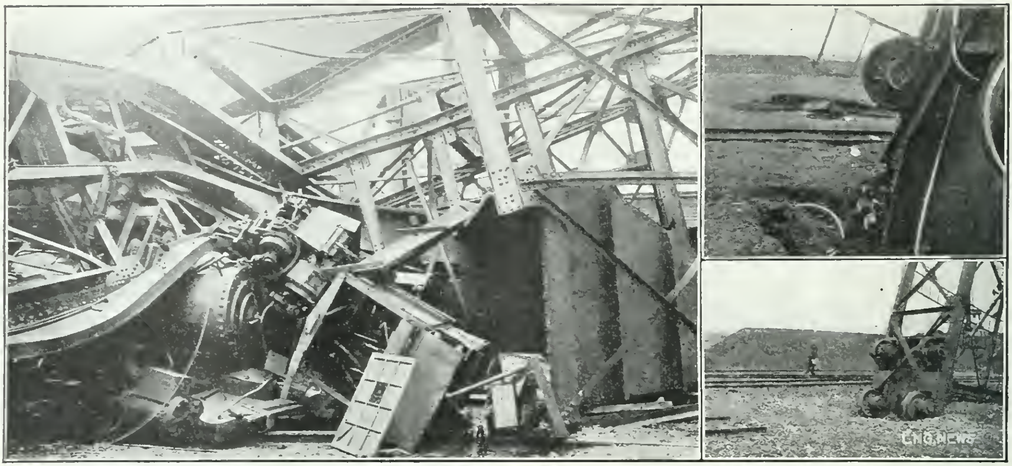


Fig. 3. (Left) Position of Yard Locomotive beneath Wreck. (Right) Details of Derailment

(The structural excellence of a locomotive boiler is exhibited in a remarkable manner in the left-hand view.)

not only wrecking itself but also a yard locomotive. The position of the crane after its fall is shown in Fig. 2. Fig. 3 shows the wreckage of the crane and the locomotive. The small views at the right of Fig. 3 show the manner in which the forward wheels sank into the ground after derailment. The bearing cap of one is shown to be broken, leaving the wheel nearly buried.

The crane is damaged beyond repair and it is expected that a new one will be erected in its place. The damage is estimated at $50,000. The crane was furnished ten years ago by the Robins Conveying Belt Co., New York City. It was braked by a locking device on a reduction shaft from the driving motor. It is claimed by the electric company that all driving wheels were locked in this manner at the time of the accident.—Engineering News.

BUSINESS ITEMS

The Champion Fibre Co., Canton, N. C., recently placed an order with Yarnall-Waring Co., Philadelphia, Penn., for 20 Simplex Blow-Off Valves, as a result of a trial of two valves since last October.

John Simmons Co., 110 Centre St., New York, has taken over the manufacturing and selling rights of the Klein Boiler Circulator "Kebec" and has established a new department, under the direction of Paul M. Klein.

The Graton & Knight Mfg. Co., Worcester, Mass., has recently opened a branch office at 301 Magazine St., New Orleans, La., where it will carry a complete line of leather belting, lace leather, belt dressing and cement.

Every engineer who registered at the booth of the Engineers' Appliance Co., of Cleveland, Ohio, at the recent craftsmen's convention, should write direct to the company for one of their new catalogs. In some way the register was lost, and for that reason the company has been unable to send the books as agreed.

The 1915 Friction Clutch Catalog of the Moore & White Co., Philadelphia, Penn., will be ready for distribution on Sept. 1. The new book is an instructive as well as interesting treatise on friction clutches, and should be in the hands of everyone interested in the subject. A copy will be sent on request.

The Whitlock Coil Pipe Co., Hartford, Conn., has opened an office in Chicago, under the management of Richard S. Bull, at 431 South Dearborn St. The Chicago office will handle the company's full line of feed-water heaters, hot water-storage and service heaters, high-pressure pipe bends, flanged joints, etc., for Chicago and surrounding territory.

A most interesting bulletin has just been issued by the National Tube Co., Frick Building, Pittsburgh, Pa., on the "Relative Corrosion of Iron and Steel as Found in Service." It contains an article by William H. Walker, Ph.D., on this subject, and also contains three other valuable articles on the subject of corrosion, namely, "Plain Facts About 'National' Pipe for the Plumber and Steamfitter," "Relative Merits of Wrought-Iron and Steel Pipe," and "Further Discussion of the Relative Merits of Wroght-Iron and Steel Pipe," by F. N. Speller, metallurgical engineer, National Tube Co. The bulletin is called Bulletin 10C. It is sent on request.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Central Gas & Electric Co., Geneva, N. Y., will issue $83,500 in bonds, the proceeds to be used for the improvement and extension of the electric-light department. A. V. Wainwright is Gen. Mgr.

Bids will be received until Aug. 26, by the Board of Freeholders, Newark, N. J., for the installation of a 300-hp. water-tube boiler an dauxiliary apparatus for the Overbrook Hospital. Runyon & Carey, Newark, are the Consult. Engrs.

The City Council, Cumberland, Md., contemplates purchasing a 300-kw. generator for the municipal electric-light plant. Joseph S. Scriver is Water and Light Comr.

SOUTHERN STATES

Press reports state that the Southern Power Co., Charlotte, N. C., contemplates establishing a steam-turbine plant to cost about $1,000,000. C. I. Burkholder, Charlotte, is Mgr.

The citizens of Bay Minette, Ala., have voted $5000 in bonds for the construction of a municipal electric-light plant. Edgar B. Kay, Tuscaloosa, is Consult. Engr.

The City of Knoxville, Tenn., contemplates installing two 350-hp. water-tube boilers and two 10,000,000-gal. vertical triple-expansion engines. Dabney H. Maury is Hydraulic Engr.

CENTRAL STATES

The Board of Bond Trustees of the Bowling Green State Normal College, Bowling Green, Ohio, has approved plans prepared for the construction of a power plant for the college.

Charles Brossman, Union Trust Bldg., Indianapolis, Ind., has been commissioned by the City Council of Huntington, Ind., to prepare plans and supervise the reconstruction of the municipal electric-light plant, for which bonds have been voted.

The Indiana Steel & Wire Co., Muncie, Ind., will install another boiler unit in its plant. The unit will be either two 250-hp., two 300-hp., one 500-hp. or one 600-hp. single-unit water-tube boiler.

According to press reports, bids will soon be received by the City Council, Elmwood, Ill., for the construction of a municipal electric-light plant.

The Superior Water, Light & Power Co., Superior, Wis., will issue $250,000 in stock. Improvements and addition to the plant will be made. W. H. Winslow is Gen. Mgr.

WEST OF THE MISSISSIPPI

Plans are being prepared for the installation of a municipal electric-light plant at Sergeant Bluff, Iowa. The estimated cost is $10,000.

Bids will be received about Sept. 15 for the construction of a municipal electric-light plant at Adams, Neb. The equipment will include two generators, a two-panel switchboard, six transformers, etc. Johnson & Johnson, Falls City, Neb., are the Engrs-in-Charge.

The Havre Electric Co., Havre, Mont., contemplates making improvements to its plant to cost $50,000. F. W. McCarthy is Mgr.

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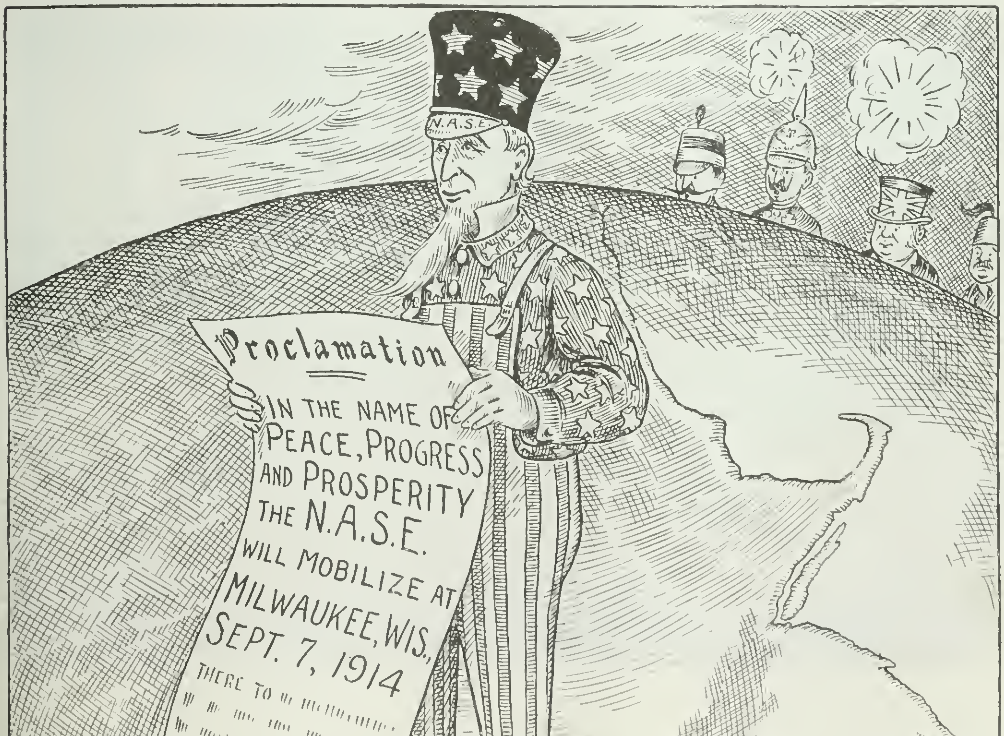
POWER

Vol. 40 NEW YORK, SEPTEMBER 1, 1914 No. 9


N.A.S.E.
Proclamation
IN THE NAME OF PEACE, PROGRESS AND PROSPERITY THE N.A.S.E. WILL MOBILIZE AT MILWAUKEE, WIS., SEPT. 7, 1914
THERE TO
I PUT THE MOB IN MOBILIZE
POWER N.Y.
McPhee

FOR PEACE, PROGRESS AND PROSPERITY!

Milwaukee's Largest Electric Station

SYNOPSIS—The Commerce St. station, Milwaukee's largest power station, has a generating capacity of 61,900 kw. and 17,000 hp. in boilers. Large low-pressure turbines take steam from cross-compound vertical engines; special governors control the supply. The coal- and ash-handling facilities are interesting. Individual steel stacks for each battery of two boilers are provided. Continuous smoke records are kept and a bonus system, which has resulted in efficient operation, is in force in the boiler room.

*

The Commerce St. station of the Milwaukee Electric Ry. & Light Co. is on the west bank of the Milwaukee River, a short distance north of the central business district of the city. It is the main generating station for this company and its subsidiaries, and is of 61,900-kw. capacity, 6000 kw. being in 25-cycle engine-driven units, 8000 kw. in 600-volt, direct-current, engine-driven generators; 15,000 kw. in 25-cycle turbo-generators, 32,500 in 60-cycle turbo-generators, and the remaining 400 kw. is an engine-driven unit furnishing 250-volt direct current for station use. The construction of the present plant may be divided into three main periods, although various pieces of apparatus have been added at different times when needed.

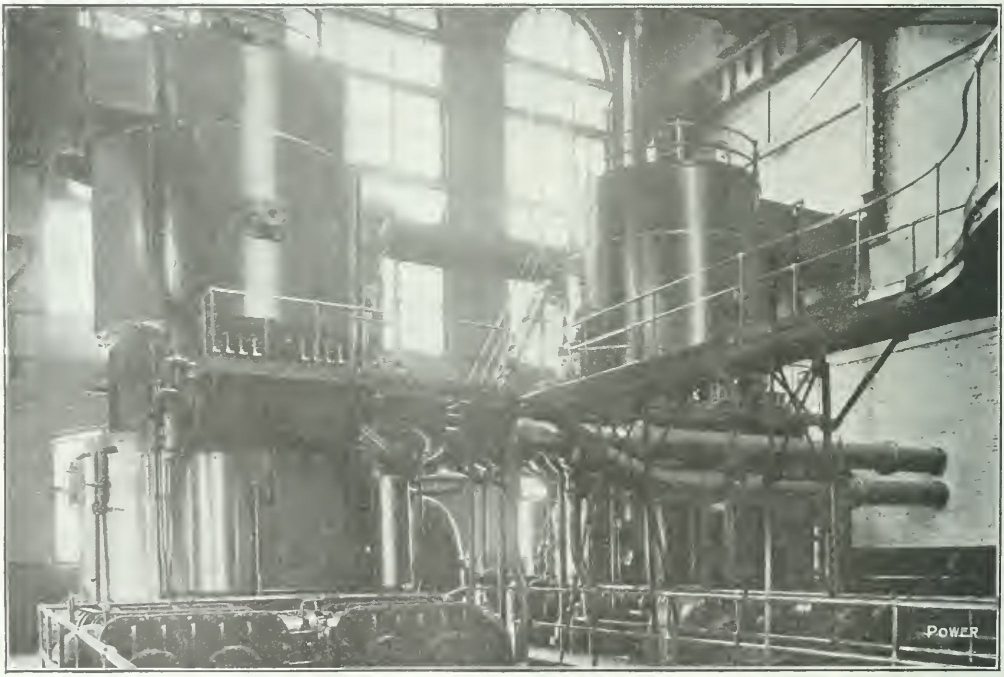


Fig. 1 14,000-Kw., High-Pressure Turbines in North End of Station

The first installation was four 1500-kw., engine-driven, 25-cycle alternators and eight 650-hp. boilers, placed in use early in 1903. Two years later four more engines, this time driving 2000-kw., 600-volt railway generators, and eight 708-hp. boilers were installed. A short time later two 1000-kw., vertical-impulse turbines were added to provide for the 60-cycle demand formerly met by the other stations. The final period of construction was in 1911 and 1912, which more than doubled the old capacity and left the station in practically its present condition. At this time all of the barometric condensers but one and the two 1000-kw. vertical turbines were removed. Two 14,000-kw., high-pressure, 60-cycle, vertical turbo-generators, Fig. 1, and two 7500-kw., low-pressure, 25-cycle turbo-generators, Fig. 2, were installed, together with eight 765-hp. boilers and auxiliaries. Since that time a 4500-kw. turbine has been added to the 60-cycle system and a 400-kw. engine has been transferred from one of the other stations to provide 250-volt direct current for station use. Twenty-five-cycle power is also received over a 120-mile transmission line from the hydro-electric station of the Southern Wisconsin Power Co., on the Wisconsin River at Kilbourn.

Engine Room

Fig. 3 is a view over the tops of the engines and shows the large exhaust pipe with the two atmospheric reliefs. The section of pipe between the last engine and the large receiver separator is 66 in. in diameter, and is fitted with a motor-operated valve of the same size. Seven engines exhaust into this header. Part of the barometric condenser for engine No. 1 can be seen at the extreme end. This engine drives a 1500-kw., 25-cycle alternator, and is used when the load is too light to justify the operation of both an engine and a low-pressure turbine, as is the case in the early morning hours, when the 25-cycle load is generally carried by the transmission line. Besides the connections from the seven engines, the auxiliary exhaust header leads into the main line, so that all of the steam not utilized in the feed-water heaters can be used in the turbines. Fig. 4 is a plan view of the entire station, showing the layout of all the engines, turbines, boilers and auxiliaries. Fig. 5 is a cross-section of the north end of the plant.

The low-pressure turbines, Fig. 2, are of the 4-stage, vertical-impulse type, and drive 25-cycle, 6600-volt generators, compensators being used to step up to 13,200 volts, the standard voltage at which this current is transmitted. The two 14,000-kw. machines, Fig. 1, are 6-stage, high-pressure vertical units of the same type, and together with the 1500-kw. turbine shown in Fig. 6, which is a horizontal reaction machine, generate 60-cycle power at 4000 volts, the standard voltage for primary distribution in the city. The 1500-kw. unit was installed to carry the load during the early morning hours and on holidays, and is also used to help out the large turbines at times of peak demand.

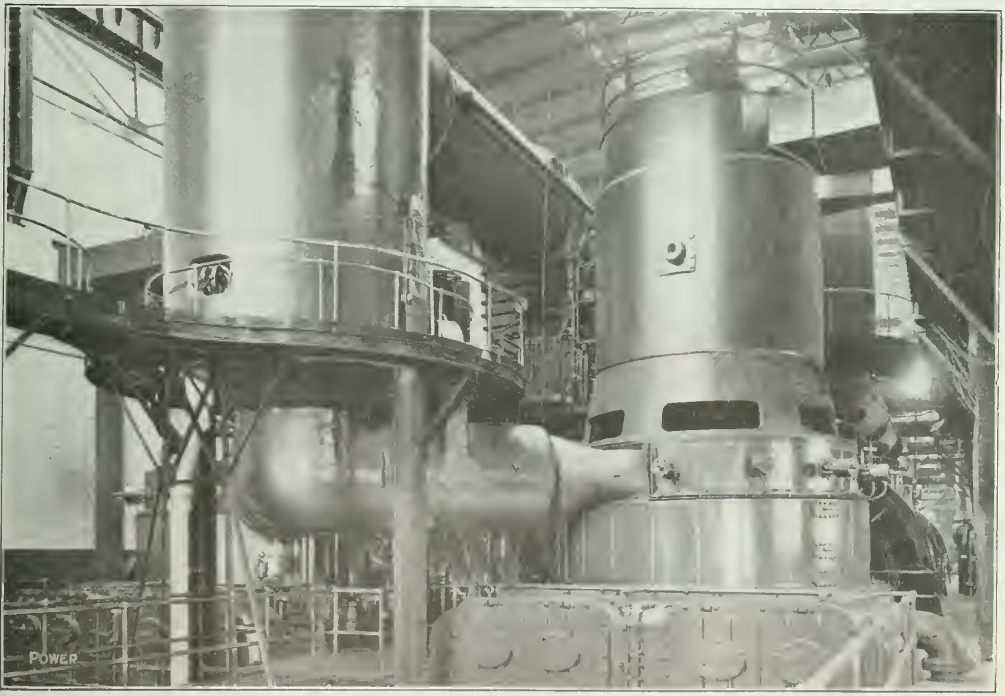


FIG. 2. LOW-PRESSURE TURBINE WITH RECEIVER, SEPARATOR IN FOREGROUND

TURBINE CONTROL BOARDS AND SPECIAL GOVERNORS

Fig. 7 shows the control board on one of the low-pressure turbines; similar boards are set upon the other machines and duplicates of each are mounted on the switchboard. The instruments at the top of the board consist of a speed indicator and wattmeter and gages showing the steam pressure, vacuum and step-bearing oil pressure. These, together with a synchroscope mounted nearby, afford the engineer all the necessary information for starting and synchronizing the machine. For communication between the engineer and the switchboard operator, an electric signaling device is used. On the board are six illuminated signals: "On," "Off," "Hold," "Increase," "Decrease" and "Off Quick." Duplicates of these are on the switchboard, and by their use all necessary communication can be quickly obtained.

The combination of three engines driving 25-cycle alternators and four driving 600-volt railway generators exhausting into 25-cycle low-pressure turbo-generators at first gave trouble in keeping the exhaust pressure constant. As the load on the engines would increase, the turbine would tend to speed up, but the speed governor on the latter unit would partly close the butterfly valve in the steam intake. The exhaust pressure would consequently rise until the relief valve opened and allowed some steam to exhaust to the atmosphere. On account of the constant fluctuations of load on the railway engines and the variations being different from those on the 25-cycle system, this condition would occur frequently. To prevent it, an additional governor was designed and put on each of the two turbines. A steam piston within a cylinder and operated by the rise and fall of the exhaust pressure was arranged to work a set of valves which controlled by compressed air four of the nozzle valves on the turbine, the other four valves being operated by hand as before.

The arrangement is shown quite clearly in Fig. 7, the governing mechanism being on the left and the hand-operated valves on the right. If the load on the engines increases, raising the exhaust pressure, the cylinder moves the rack-and-pinion combination, so placing the air valves that the nozzle valves are opened, admitting more steam to the turbine and lowering the pressure. The speed governor is set one cycle high, so as not to interfere with the operation of the other governor. This system has proved successful, and the exhaust pressure is always kept close to the 16 lb. per sq.in. that is needed for the best operation of the turbines.

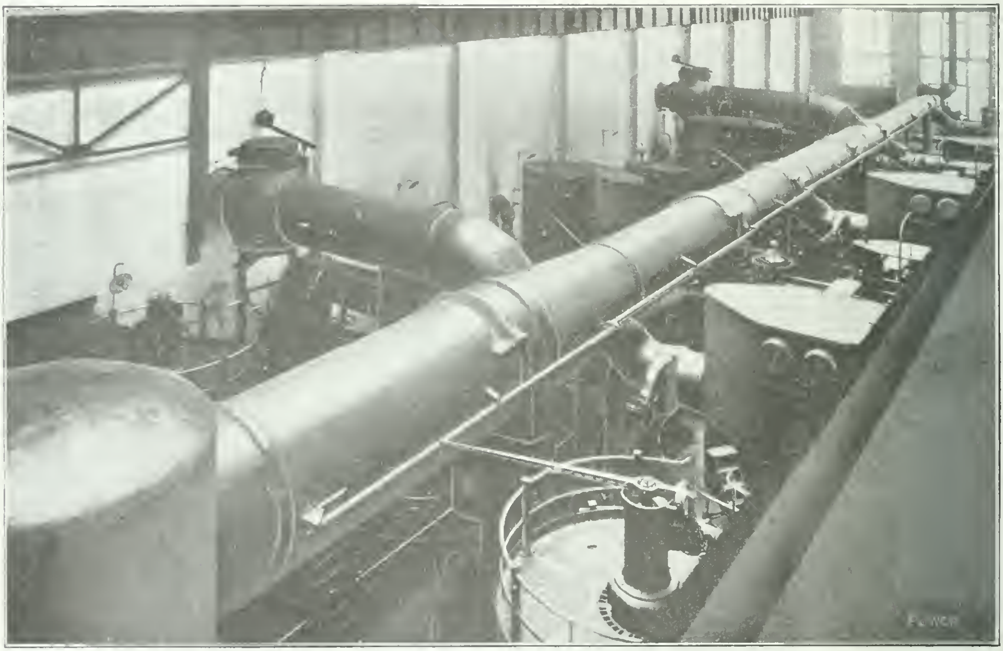


Fig. 3. View of Exhaust Header from Engines to L. P. Turbine

Vacuum Measured by Thermometers

On the turbines the method of measuring the vacuum is unusual. Instead of the familiar recording vacuum gage, a thermometer is used, with the thermometer element placed in the path of the steam directly below the last wheel of the turbine. The charts used can be read either in degrees or in inches of vacuum corresponding to that temperature. This method has worked out well, as it not only gives accurate results, but also shows the back pressure without making corrections for barometric conditions.

Condensing Equipment

From the plan and sectional view of the north end, the general layout of the condensing apparatus can be seen. Cooling water is received from an intake tunnel tapping the river directly north of the station. A revolving, motor-driven screen just inside the station removes all the solid particles not taken care of by the wide-mesh screen at the mouth of the tunnel. The surface condensers are of the base type, with 25,000 sq.ft. of cooling surface, and the four sets of equipment are identical. A 36-in. centrifugal pump driven by a corliss engine supplies the cooling water, and a 31x24-in. air pump, in tandem with the engine cylinder, takes care of the air collecting in the condenser. The condensed steam is removed by a 5-in., two-stage centrifugal pump, which elevates the water into large storage tanks. Each pump is driven by a 24-hp. horizontal steam turbine or a 25-hp. induction motor. Usually, the motor does not furnish any power, but is kept floating on the line ready to pick up the load in case of trouble with the turbine. Two 4000-sq.ft. surface condensers, two 14-in. centrifugal, motor-driven circulating pumps, two vertical engine-driven air pumps, and one 3-in., two-stage motor-and-turbine-driven hotwell pump comprise the condensing equipment for the 4500-kw. turbine. The reason for this unusual arrangement of two condensers on one turbine was due to the dismantling of the two 1000-kw. turbines. The condensers and pumps were still in good condition and were made use of in this way. The barometric condenser on engine No. 1, which can be seen in the general layout, is fitted with a 10-in. motor-driven centrifugal pump and an engine-driven air pump.

Exciters

Four 75-kw., 125-volt exciters furnish the direct current for excitation in the station, three being near the large turbines and one beside the engine-driven alternators. All connect to the same busbar and are driven by horizontal turbines, operating noncondensing. In addition, a storage battery is kept on the bus at all times for reserve. Direct current can also be obtained from a downtown station or from the 400-kw. engine-driven set, so that the danger of any interruption to excitation is remote.

BOILER ROOM

Installed in the boiler room are 24 water-tube boilers, eight being of 650-hp. each, eight of 708-hp. each, and the remaining eight of 765-hp. each. The total capacity of 16,984 hp. gives 3.64 kw. installed capacity for each rated boiler horsepower installed, although in operation the ratio is about 1½ to 1, installed capacity. As indicated in Fig. 8, each battery of two boilers is equipped with its own steel self-supporting stack, 8 ft. in diameter and 100 ft. high. Sixteen are fired by underfeed stokers, with automatic attachments; seven with gravity underfeed stokers (see Fig. 9), and one with a self-cleaning underfeed stoker. The forced draft necessary is supplied by fans in the pump room directly below the boilers. The coal burned is Youghiogheny screenings and is stored in bunkers running the entire length of the station immediately above the aisle between the rows of boilers, coal chutes running down each stoker.

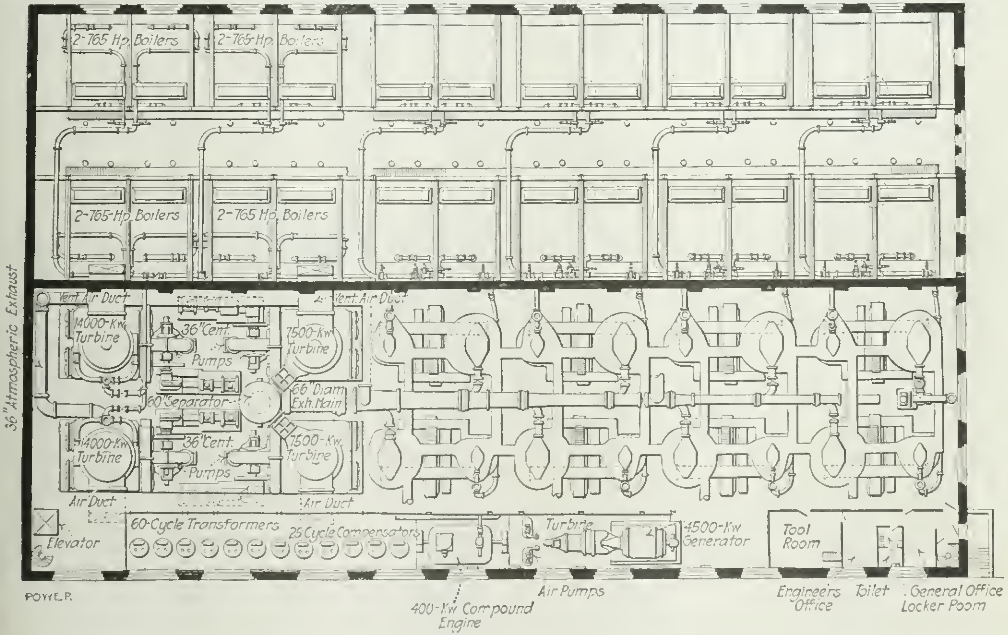


FIG. 1. PLAN VIEW OF THE COMMERCE STREET STATION

Superheaters, consisting of several rows of tubes above the drums, are on all the boilers and raise the temperature of the steam about 10 deg. Eight boilers, the 765-hp. units, are equipped with additional superheaters, which raise the superheat to about 150 deg. As most of the steam from the large boilers is used in the high-pressure turbines, high superheat is desirable, but the lower superheat from the other boilers is sufficient for the engines.

Each boiler is equipped with an indicating steam-flow meter, mounted where it may be seen readily by the firemen, and with the target set at the most economical boiler rating as determined by tests. An illuminated differential draft gage showing the draft over the fire is placed on the side of each boiler close to the stack damper regulator, to facilitate keeping the furnace draft at the correct pressure. An illuminated gage is also provided for the air pressure in the wind box beneath the fire, and the air damper regulator placed close at hand so that the forced draft can be kept at the most efficient point.

Besides the two regular feed lines to each boiler, there is a connection to a test line running the entire length of the boiler room, making it possible to isolate any boiler or boilers for testing purposes. Feed-water regulators are placed on the feed lines to each boiler, and an injector for emergency use is also installed for each unit.

The boiler-room piping is so arranged that the boilers can either furnish steam to the engines or turbines or into the subheader, which is the stretch of 10- and 12-in. piping running the entire length of the plant. All subheader piping is of steel, with cast or ferrosteel fittings, as is also the piping in the north end and to the turbines. A 5-in. auxiliary steam header runs through the pump room, supplying steam for the feed pumps and turbines there. Steam for the turbine auxiliaries is taken directly from the turbine headers. The 4500-kw. turbine and the 400-kw. engine and auxiliaries, together with the low-pressure turbine auxiliaries, are fed from a steam line in the form of a loop, tying into the subheader in two places. All boiler, subheader and header tie valves are motor driven, the control cabinets being on the engine-room side of the division wall.

SMOKE INSPECTION

On the edge of the roof and affording a full view of the tops of all the stacks, is the smoke observer's shanty. A system of electric signaling devices connects the shanty with the boiler room, so that when the observer notices a stack smoking, he turns on a switch, causing a bell to ring and a light to burn down in the boiler room near the battery making the smoke. The firemen can readily tell what boiler or boilers are producing smoke, and to let the smoke observer know his signal has been understood, the bell is turned off. The light, however, can be turned off only from the roof, and remains lighted until the stack stops smoking. In addition to tending these signals, the smoke observer keeps a record of the time each stack smokes and the quality, so that at the end of the day's run the superintendent knows just how his station has performed in this regard. This report, along with all other station records, is sent to the office of the chief engineer of power plants each morning and forms a valuable adjunct in coöperating with the smoke-abatement work carried on by the city.

PUMP ROOM

The pump room is directly beneath the boiler room, and in it are the feed-water heaters, the feed pumps, boiler fans, house pumps and other miscellaneous equipment. There are six feed-water heaters of the open horizontal type, four in the south end of the station and two in the new addition. The supply of feed water is obtained from the storage tanks fed by the hot-well pumps on the turbines. The water is pumped from these tanks to the heaters by a 10-in., motor-driven, centrifugal pump and by an 8-in., double-suction pump driven by a 40-hp. turbine. Six pumps deliver the water to the boilers, four being 18 and 10 by 18-in. duplex, outside-packed, pot-type pumps, and two 14x26 and 8x24-in. cross-compound, engine-driven, outside-packed, pot-type pumps. Two of the smaller pumps are used for the high-pressure water supply, only one being kept running continuously. This water is used for wetting down ashes, cleaning boilers and for all purposes where high-pressure water is needed.

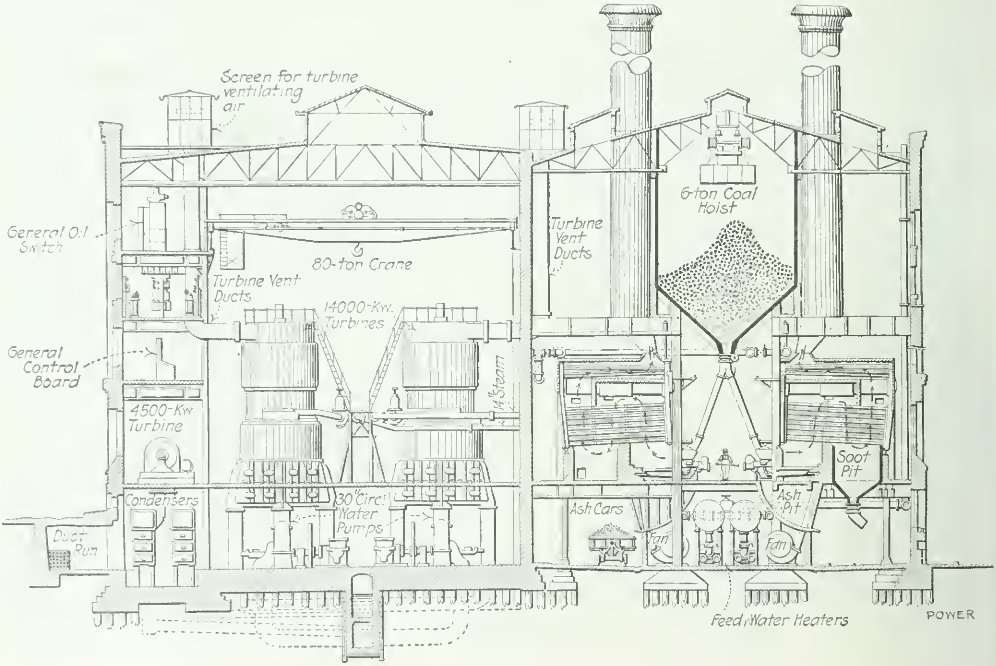


FIG. 5. SECTIONAL ELEVATION OF THE COMMERCE STREET STATION

Four 4-in. motor-driven, centrifugal pumps furnish the low-pressure water which is used in the cooling jackets of the air pumps and as make-up water for the storage tanks. Both high- and low-pressure pumps take their water from the discharge tunnel for the circulating pumps, and there is a connection between the two systems for emergency in case of any failure of the motor-driven pumps. High-pressure water can be fed into the low-pressure line through proper reducing valves. In the pump room are also the fans for the boiler forced draft. Those for the 650-hp. boilers in the south end are driven by 24-hp. induction motors, those for the 708-hp. boilers by 25-hp., 600-volt, direct-current motors, while the 765-hp. boilers each have two blowers driven by a 60-hp., 5-stage horizontal turbine, which also furnishes the power for driving the gravity underfeed stokers. The testing equipment, described later, and the two motor-

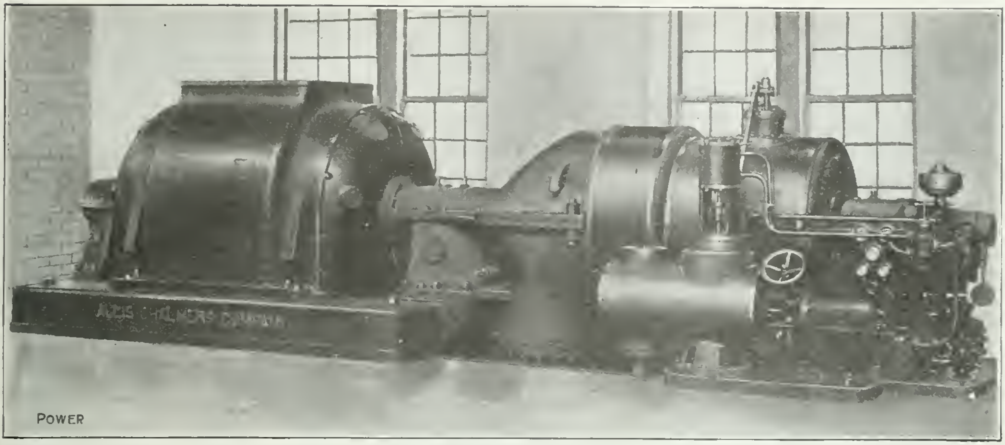


Fig. 6. View of 4500-Kw. Turbine

driven and one steam-driven air compressors are also in the pump room.

Coal and Ash Handling

Coal is received by boat from a nearby fuel company, the boat being fitted with a belt conveyor and also supplying the downtown station. Because of the large amount stored at the company's yards, it is not necessary to keep any great supply at the station, as, in case of any trouble with the water route, coal can still be received in wagons. Consequently, the only storage is in the bunker over the center of the boiler room between the rows of stacks. This bunker holds about 2000 tons, or three days' supply.

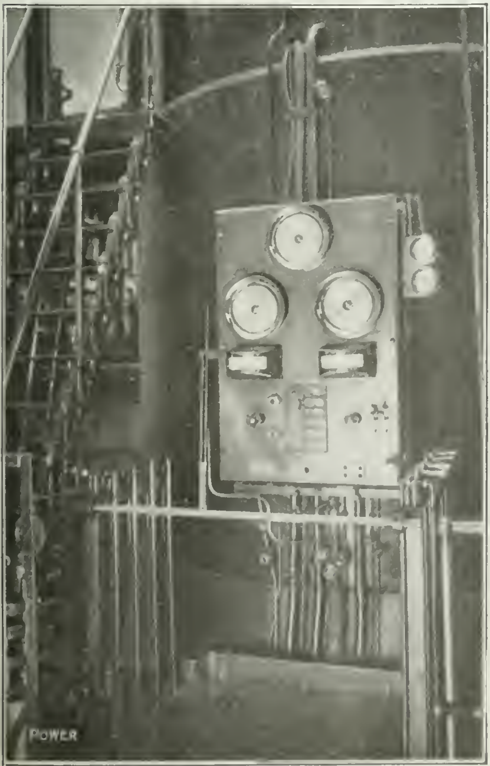


Fig. 7. Control Board on Low-Pressure Turbine; Also Air Valves and Mechanism on Governor

The coal from the boat is discharged into a 15-ton hopper at the north end of the station, equipped with an automatic slide door and chute, and is fed from there into an 8-ton iron coal box resting on a 20-ton platform scale. The coal is weighed and hoisted to the top of the building by the crane suspended on a track over the bunkers. This permits the crane operator to dump the coal at any point along the bunker. One man is needed on the crane and one at the scale.

There are one 6- and one 5-ton single-track cranes at the south end of the building, together with a 20-ton platform scale and several coal boxes. These were used to unload the coal from wagons when that method was employed, and are now used as reserves.

The removal of the ashes from the hoppers to the cars is a simple process. The general layout of the hoppers

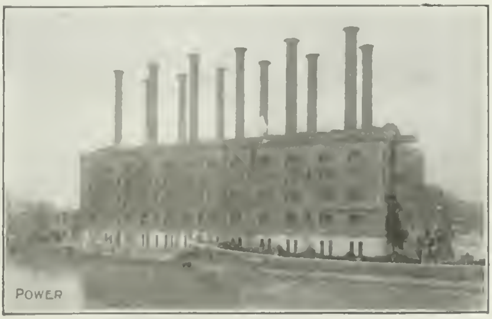


Fig. 8. The Commerce St. Station as Seen from the River

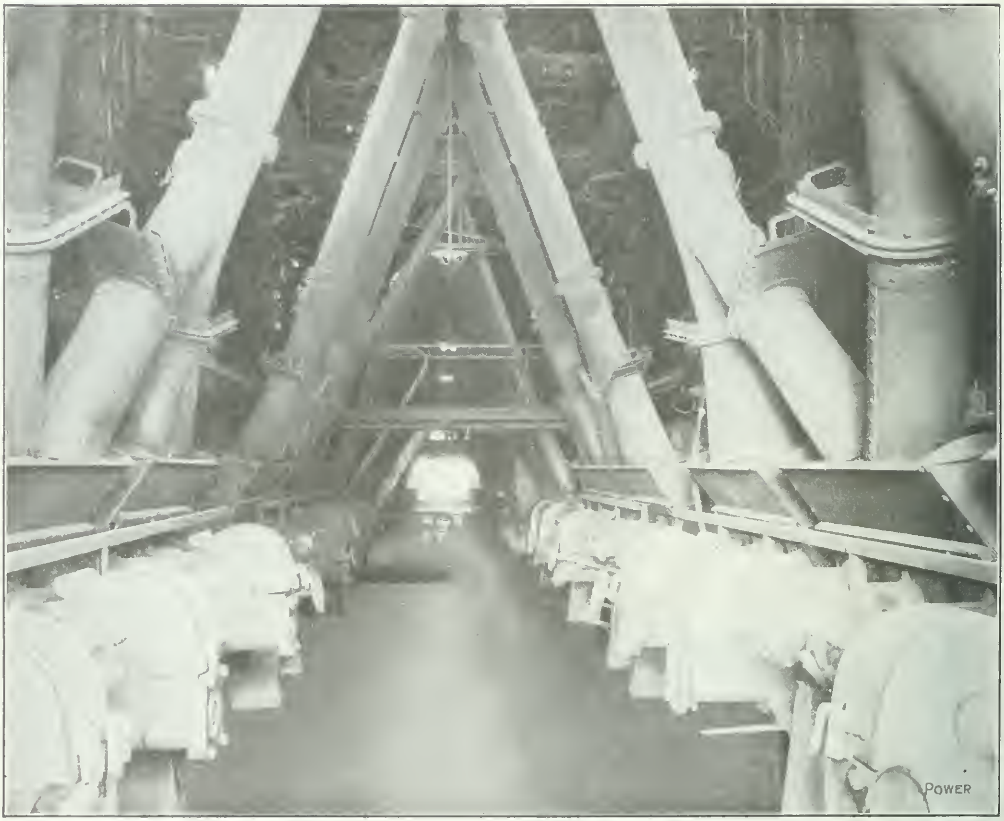


Fig. 9. North End of Boiler Room, Showing Taylor Stokers

is shown in the cross-sectional view of the station, and it is clear that the ash cars can be placed beneath each hopper. At various points in the hopper there are jet nozzles, and when the air-operated doors are opened, the water is turned on and the ashes flushed out into the cars. All but the largest clinkers are removed by this process; these are pulled out with an ash hoe. Tracks run the entire length of both ash alleys, and a storage-battery locomotive, hauling three cars at a time, furnishes the necessary motive power. At the north and south ends of the east alley are two conveyors into which the ashes can be dumped. These carry the ashes out into a scow in the river which is towed out on Lake Michigan and dumped.

Testing Equipment

A separate feed line runs to each boiler and connects with a 10 and 5 by 12-in. duplex feed pump in the north end of the pump room. This pump takes its supply from a large storage tank sunk below the basement floor immediately beside it. Above the tank is a 2500-lb. automatic dumping scale which weighs all the water fed into the tank. The arrangement is compact and one man can operate the scale and pump and take all the necessary readings. This outfit can also be used for turbine tests, as the discharge of any of the hot-well pumps can be changed to feed into the tank through the scale. A 5-in., motor-driven centrifugal pump is provided to empty the tank in a test of this nature. The testing equipment on the boilers is complete, thermometer wells being placed wherever necessary and piping run to various parts of the setting to permit CO_2 and draft readings to be quickly taken.

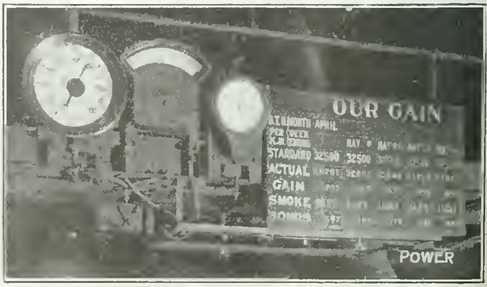


Fig. 10. Bonus Board, Boiler Horsepower Meter and Master Steam Gage

In the southwest corner of the basement is a machine shop, in which are all the machines needed for the work that constantly arises in a plant of this size. All but the largest jobs can be done here, and with the modern equipment a considerable saving is effected over the cost of outside work. A waste-washing outfit is also in the basement, where a large amount of oil, suitable for further use after proper treatment, is extracted from the waste and rags. Directly beneath the entrance are shower baths and lockers for the men. The superintendent and his assistants have offices at the entrance to the building in the southwest corner, where all th charts and records are brought before being sent to the main offices. There is a completely stocked store and tool room beside the offices, where most of the supplies are kept.

PRINCIPAL EQUIPMENT OF THE COMMERCE ST. STATION
MILWAUKEE ELECTRIC RAILWAY AND LIGHT CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Vertical Curtis six-stage	14,000 kw.	Main units	180 lb. steam, 720 r.p.m., 4000 v., 3-phase, 60-cycle	General Electric Co.
2	Turbines	Vertical Curtis four-stage	7500 kw.	Main units	Low pressure, 750 r.p.m., 6600 v., 3-phase, 25-cycle	General Electric Co.
1	Turbine	Horizontal parsons	4500 kw	Main units	180 lb. steam, 1800 r.p.m., 4000 v., 3-phase, 60-cycle	Allis-Chalmers Co.
4	Engines	Vertical cross-comp	2000 kw., 32x68x48 in.	Main units	180 lb. steam, noncondensing, 600 v., direct connected	Allis engines Gen. Elec. Generators.
3	Engines	Vertical cross-comp.	1500 kw., 28x60x48 in.	Main units	180 lb. steam, noncondensing, 13,200 v., 3-phase, 25-cycle	Allis engines, Gen. Elec. generators
1	Engine	Vertical cross-comp	1500 kw., 28x60x48 in.	Main units	180 lb. steam, condensing, 13,200 v., 3-phase, 25-cycle	Allis engines, Gen. Elec. generators
1	Engine	Vertical cross-comp.	400 kw., 18x36x30-in.	Station auxiliary power	180 lb. steam, noncondensing, driving two 200 kw., 125 v., d.c. gen.	Allis engines, Gen Elec. generator
4	Turbines	Horizontal Curtis	75 kw	Exciters	180 lb. steam, connected to 125 v., d.c. gen., r.p.m.	General Electric
4	Condensers	Surface	25,000 sq.ft.	14,000 and 7500 kw. turbines		H. R. Worthington
2	Condensers	Surface	4000 sq.ft.	4500 kw. turbine		F. M. Prescott Steam Pump Co.
1	Condenser	Barometric	2500 hp.	1500 kw engine		H. R. Worthington
4	Pumps	Centrifugal	36-in., 30,000 g.p.m.	Circulating pumps	Each driven by Laidlow-Dunn-Gordon Corliss engine, noncondensing	H. R. Worthington
2	Pumps	Centrifugal	12-in., 4200 g.p.m.	Circulating pumps for 4500 kw. turbine	Each driven by 30 hp., 60-cycle, 220 v., ind. motor	Lawrence Machine Co.
1	Pump	Centrifugal	10-in., 2000 g.p.m.	1500 kw. engine	Driven by 50 hp. ind. motor	H. R. Worthington
4	Pumps	Dry vacuum	31x24-in.	14,000 and 7500 kw. turbines	In tandem with above engines driving circ. pumps	Laidlow-Dunn-Gordon Co.
2	Pumps	Dry vacuum	10x18x16-in.	4500 kw. turbine.	Engine driven, vertical	F. M. Prescott Steam Pump Co.
1	Pump	Dry vacuum	8x16x12-in.	1500 kw. engine	Engine driven, vertical	H. R. Worthington
4	Pumps	Centrifugal wet vacuum	3-in. two-stage, 600 g.p.m.	Hotwell pump for 14,000 and 7500 kw. turbines	Each driven by 25 hp. ind. motor and 24 hp. Curtis horizontal turbine	H. R. Worthigton
1	Pump	Centrifugal	3-in. two-stage, 200 g.p.m.	Hotwell pump for 4500 tur	Driven by 15 hp. ind. motor and 14 hp. Kerr turbine	H. R. Worthington
4	Pumps	Duplex	12x3x18-in.	Step bearing on vertical tur.	Steam driven	H. R. Worthington
4	Pumps	Duplex	9x5¼x10-in.	Oil for vertical turbines	Provided with 2-in. Elliott strainers	Blake & Knowles Steam Pump Works
7	Pump	Duplex	3½x2x3-in.	Oil for engines		F. M. Prescott Steam Pump Co.
1	Pump	Centrifugal	1½-in., 55 g.p.m.	Discharge of trap lines to storage tank	Driven by 10 hp. ind. motor	Lawrence Machine Co.
1	Pump	Centrifugal	1½-in., 55 g.p.m.	Cooling water for step bearing oil tanks	Driven by 5 hp. ind. motor	Lawrence Machine Co.
8	Boilers	Water-tube	650 hp.	Generate steam.	180 lb. pressure, 40 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
8	Boilers	Water-tube	708 hp.	Generate steam	180 lb. pressure, 40 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
8	Boilers	Water-tube	765 hp	Generate steam	180 lb. pressure, 150 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
24	Superheaters	Edge Moor		On all boilers	40 deg. superheat	Edge Moor Iron Co.
8	Superheaters	Foster.	44 elements	On 765 hp. boilers	150 deg. superheat	Power Specialty Co.
16	Stokers	Jones under-feed		On 650 and 708 hp. boilers.	Operated by Cole automatics	Under-feed Stoker Co. of America
1	Stoker	Jones under-feed self-cleaning		On one 765 hp. boiler	Operated by Cole automatics	Under-Feed Stoker Co. of Am.
7	Stokers	Taylor under-feed		On seven 765 hp. boilers	Driven from fan shaft in basement.	American Engineering Co.
8	Fans	National		Forced draft for 650 hp. boilers	Driven by 20 hp. ind. motors	National Blower Co.
8	Fans	Bayley		Forced draft for 708 hp. boilers	Driven by 25 hp., 600 v., d.c. motors	Wm. Bayley & Sons
16	Fans	A.B.C. Sirroco		Forced draft for 765 hp boilers	Each set of two driven by 60 hp. 5-stage hor. Kerr turbine	American Blower Co.
21	Steam flow meters	G. E. indicating, type F. S.-2		On all boilers		General Electric Co.
2	Feed water heaters.	Open	5000 hp.	Heat feed water.	Exhaust steam	Hoppes Mfg. Co.
4	Feed water heaters.	Open	1500 hp.	Heat feed water	Exhaust steam	Hoppes Mfg. Co.
2	Pumps	Outside packed, pot type	14x26x8x24-in. 1000 g.p.m.	Boiler feed.	Cross comp. eng. driven	F. M. Prescott Steam Pump Co.
4	Pumps	Duplex	18x10x18-in., 400 g.p.m.	Boiler feed.	Steam driven	F. M. Prescott Steam Pump Co.
1	Pump	Duplex	10x5x12-in., 120 g.p.m.	Boiler testing	Steam driven	F. M. Prescott Steam Pump Co.
1	Pump	Centrifugal	10-in., 2000 g.p.m.	Feed water from tanks to heater	Driven by 50 hp. ind. motor	H. R. Worthington
1	Pump	Centrifugal	8-in., 1650 g.p.m.	Feed water from tanks to heater	Double suction volute, driven by 40 hp. Terry turbine	H. R. Worthington
1	Pump	Centrifugal	5-in., 734 g.p.m.	Test tank	Driven by 10 hp. ind. motor	Lawrence Machine Co.
2	Pumps	Centrifugal	4-in., 430 g.p.m.	Low pressure water supply	Driven by 10 hp. ind. motor	H. R. Worthington
2	Pumps	Centrifugal	4-in., 430 g.p.m.	Low pressure water supply	Driven by 15 hp., 600 v., d.c. motor	Lawrence Machine Co.
1	Crane	Double track	16,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Single track	12,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Single track.	10,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
2	Scales	Howe platform	40,000 lb.	Weighing coal	Equipped with self registering beam	Howe Scale Co.
2	Conveyors.	Bucket.	31 buckets.	Handling ashes	Enclosed casing, operated by 10 hp. motor	Chain Belt Co.
1	Scale	Automatic	2500 lb.	Testing	Avery water weighing scale	Avery Scale Co.
1	Crane	Traveling	80-ton.	Engine room	Motor operated	Toledo Bridge & Crane Co
1	Crane	Traveling	30-ton	Engine room	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Traveling.	6-ton.	Engine room	Motor operated	Pawling & Harnischfeger Co.

Bonus System

Perhaps the most interesting feature of the entire station is the system of bonus payment for the men, which enables them to receive a share of the profits accruing from economical and efficient operation. After careful investigation, the engineers of the company decided upon a certain B.t.u. standard per switchboard kilowatt-hour that could be expected from good operation obtained by careful attention to duty by all the men. Any saving below this figure can be figured back into dollars and cents, and a certain percentage divided among the men, those participating being men whose work bears directly on operation, as engineers, oilers, boiler-room foremen, firemen, coal passers, switchboard operators, attendants, etc. All smoke fines are deducted from the total bonus due the men in the month that the fine is made.

The bonus is expressed in percentage of the men's wages, which means that a fireman earning about $75 per month, in a month when a 5 per cent. bonus is made, receives a check for $3.75 in addition to his regular wage. To keep up interest, what is known as the "bonus board" is set up in the boiler room, as shown in Fig. 10. The results each week are figured out and the percentage bonus, based on an average weekly pay roll, is posted. From this the men can tell whether they did well the past week, and if they see a loss they can look for the cause and remedy it. The results of this system have been readily apparent since its adoption almost ten months ago. Each man has tried his best to follow out his instructions, as he realizes that they tend toward more economical operation, and consequently a larger bonus check at the end of the month.

Beside the bonus board is an illuminated master steam gage, a recording steam gage and a boiler-horsepower meter. The latter is simply a wattmeter calibrated to read in boiler horsepower in accordance with the kilowatt-hour per boiler-horsepower standard. This serves as a guide to the firemen as to the number of boilers to be kept on the header, so that the pressure may be kept constant and each boiler at its most economical rating.

John Anderson is chief engineer of power plants for the company and Fred Dornbrook is in charge of the operation of the Commerce St. plant. To the former we are indebted for the information contained in this article.

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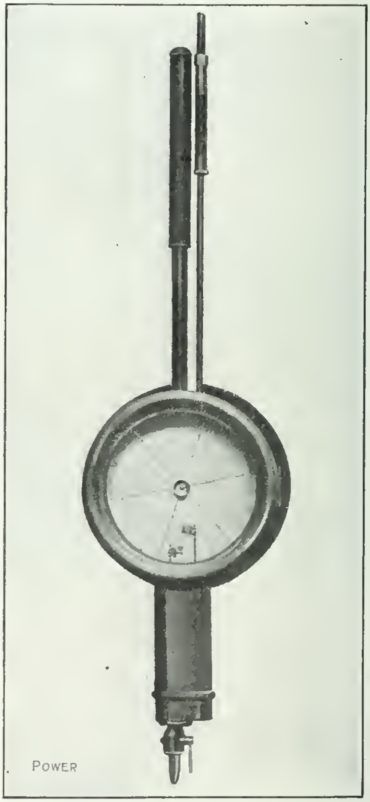
Uehling Barometer and Vacuum Recorder

One of the most important factors in the economy of steam consumption for power purposes is the absolute back pressure. To reduce this pressure to a minimum is the office of the condenser, and it is, therefore, most desirable to keep close tabs on the condenser. Vacuum gages and recorders are used for this purpose.

Ordinary vacuum gages and recorders, however, do not indicate or record the back pressure directly or correctly. The vacuum as recorded varies with the barometer at the time and place, whereas the absolute back pressure in the condenser is independent of the barometric pressure, but is always equal to the difference between the two. The nearer the vacuum approaches the barometer, the lower the back pressure, and *vice versa*.

The Uehling Instrument Co., Passaic, N. J., has put on the market a combined barometer and vacuum recorder which puts these two records in juxtaposition on the same chart. Using the barometer record as the base line, the absolute back pressure can be correctly read off directly from the chart. The instrument is shown herewith.

It consists of two float chambers, one connected with a barometric mercury column, the other with a mercury column in communication with the condenser. These columns and double float chambers are secured to the case of the recorder. The pens are actuated by the floats and move in harmony with the barometric pressure and the vacuum.



Uehling Barometer and Vacuum Recorder

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Combustion—By combustion is meant the chemical union of the combustible material of a fuel and the oxygen of the air. The fireman is the manufacturing chemist. Theoretically the process is a simple one as it is only necessary to bring the fuel at kindling temperature in contact with the correct amount of oxygen and combustion will be complete. In practice, however, the size and character of fuel and its impurities type of furnace, draft, mechanical and human difficulties enter in, causing the combustion to become less perfect and the fireman becomes less of a chemist and more of a coal heaver

Short-Circuits and Grounds in Field Coils

By F. A. Annett

SYNOPSIS—The causes and effects of short-circuits and grounds in field coils and how to locate them by means of a lamp or voltmeter.

Short-circuits in the field coils of a motor or generator may be caused in several ways: First, if the two terminals of the coil come in contact with one another, as at *a*, Fig. 1; this would completely short-circuit the coil, consequently, no current would pass through the winding of coil *A*. Second, a partial short-circuit of the winding, as at *b*, Fig. 1, is caused by the insulation breaking down between two turns in different parts of the coil. One of the chief causes of this is, when the coil is being taped the outside end turns are sometimes allowed to become misplaced and fall in upon the end of the coil after reaching the inner layers; high voltages exist between these outside and inner turns, and if the field circuit is opened suddenly the induced voltage may be high enough to break down the insulation. Third, moisture in the field coils will cause short-circuits, or grounds. A fourth cause of partial short-circuits is grounds under various conditions, some of which are two grounds in the same field coil, as at *a*, Fig. 2, which will cause a partial short-circuit of coil *A*. This has the same effect as that shown at *b*, Fig. 1.

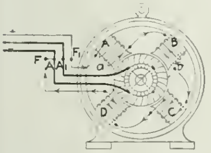


FIG. 1

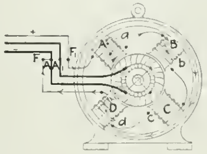


FIG. 2

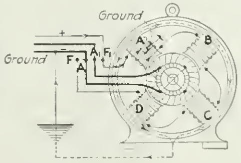


FIG 3

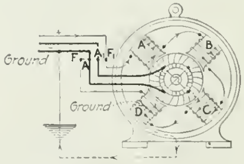


FIG 4

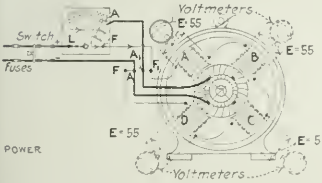
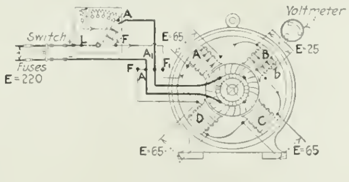


FIG 5



FIG

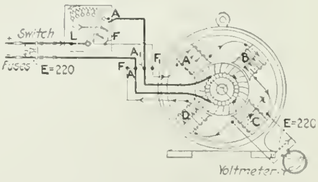


FIG.7

Methods of Locating Short-Circuits and Open Circuits

Again there may be a ground in two different coils, as at *b* and *d*, Fig. 2; this short-circuits part of coils *B* and *D* and cuts out coil *C* entirely as indicated by the dotted lines which show the path the current will take. If the frame of the machine and one side of the line is grounded, one ground in the field coil will short-circuit one or more coils depending upon which is grounded. For instance, referring to Fig. 3, if coil *A* is grounded to the core, current can flow from the positive side of the line to the field terminal F_1 through part of field coil *A* to the frame of the machine, then to the ground and back to the negative side of the line as indicated by the dotted lines and arrowheads. A condition like this would cause the fuses to blow or the circuit-breaker to open with very bad heating or a complete burn-out of the grounded coil. On the other hand, if the ground is in coil *D*, as in Fig. 4, only part of coil *D* would be short-circuited, the current flowing as indicated, and the effect would be that of a partial short-circuit such as at *b*, Fig. 1. One ground in the field coil where everything else is insulated from ground will not have any effect upon the operation of the machine.

A ground in the field winding, combined with a ground in the armature, or the controlling device, may produce several effects, depending upon the conditions under which it occurs therefore, in case of trouble on a machine one of the first things is to test the various parts for grounds.

A short-circuit in one of the field coils of a two-pole motor will not have any effect upon its operation other than cause a slight increase in speed. However, the temperature of the two coils will be different depending upon how much of the defective coil is short-circuited. The heating in the good coil may become excessive and it will be burned out unless the defective coil is repaired. With any other number of poles, if one coil is short-circuited, the machine will start up with a good effort but will spark and burn badly at the brushes and if the starting resistance is cut out the fuses will blow.

Locating Short-Circuits

One method of locating a short-circuited coil is: First, connect the coils to the line or, if the machine is already connected, disconnect the armature lead at the starting box, close the switch, and move the starting-box arm over to the running position as in Fig. 5. After the field coils have been connected to the line for

15 or 20 minutes the defective coil may be located by noting the comparative temperatures of the different coils with the hand; the defective coil will be much cooler than the others.

A better method of testing for short-circuits is to use a voltmeter for measuring the drop across each coil as indicated in Fig. 5. If none of the coils is defective the voltmeter reading across each coil will be equal to the line voltage divided by the number of coils. For instance, the drop across each coil of a four-pole machine connected to a 220-volt circuit should equal 220 ÷ 4 = 55 volts. If one coil is short-circuited the voltage drop across the defective coil will be less than that across the others, producing a condition similar to that in Fig. 6, which shows coil *B* short-circuited at *b*, therefore, the voltage drop across it will be less than across the other coils which, in this case is assumed to be 65 volts as indicated, while across the defective coil the voltmeter reading is only 25 volts. If the coil were completely short-circuited, as at *a*, Fig. 1, the voltmeter when connected across its terminals would read zero and indicate one-third line voltage across the terminals of the other three coils.

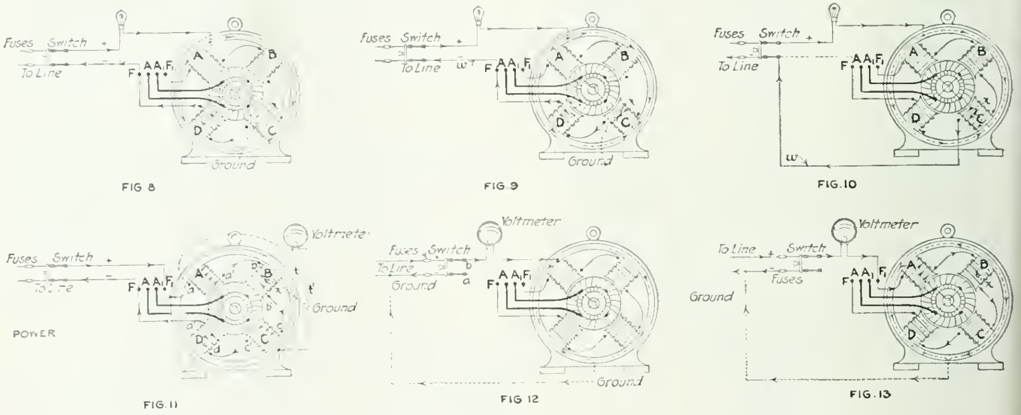


FIG 8 FIG 9 FIG. 10

FIG. 11 FIG 12 FIG. 13

METHODS OF LOCATING GROUNDS

Open-circuited coils can be located in the same way, as indicated in Fig. 7. When the voltmeter is connected across the terminals of coil *C*, which is shown open circuited at *x*, it will read the line voltage, for it completes the circuit through the other three coils. If it is connected across the terminals of any one of the other three coils it will read zero.

Instead of using a voltmeter to locate the short-circuited coil a lamp may be employed, although not with the same degree of satisfaction as with the voltmeter. When the lamp is used the defective coil will be indicated by the lamp glowing dimmer when connected to its terminals than when connected to the other coils.

If the field coils are not wound on spools the short-circuit is usually easily located and repaired. After the tape has been removed from the coil, if the short-circuit cannot be located, it is well to connect the coil again and make another test to make sure that the short-circuit has not been removed in some way in removing the tape. If it is still found to be defective the only remedy is rewinding.

TESTING FOR GROUNDS

To test the field coils for a ground a lamp may be used, as shown in Fig. 8. With the machine otherwise disconnected from the line, connect one side of the line to one terminal of the field coils then connect the lamp from the other side of the line to the frame of the machine. If one of the coils is grounded to the frame as at *x* the lamp will light. The particular coil that is grounded may be located as follows: Open a connection between the coils so as to divide them in two equal groups as in Fig. 9 and test each group separately for grounds which in this case would be found to be in the group containing coils *C* and *D*. After the group with the ground has been located, open the connection between each individual coil in this group and test each coil for a ground, as indicated in Fig. 10, which in this case would be found in coil *C*.

A ground in the field coil may also be located by means of a voltmeter, as in Fig. 11. Connect the coils to the line, then connect one terminal of the voltmeter to the frame of the machine and with the other test the different coil terminals and note the readings. For instance, consider a condition as shown, where coil *B* is grounded at *x*. If the voltmeter is connected to coil terminal *a* it will read the voltage drop across coil *A* and part of coil *B*, the latter depending on how near the ground is to *b* or b^1. If the voltmeter is now connected to *b* it will read less than one-fourth the line voltage, and if connected to *c* it will again read less than the line voltage divided by the number of coils which indicates that the ground is in coil *B*. This may then be disconnected and tested separately with a lamp, or voltmeter as described for Fig. 10.*

If one side of the line and the frame of the machine is grounded, as in Figs. 3 and 4, the method of testing the field coils for grounds would be practically the same as previously described. However, the first thing is to find the side of the line that is not grounded. This can be done as shown in Fig. 12. With the machine disconnected from the line, connect one side of the test lamp or voltmeter to the frame of the machine and with the other connect first to one side of the line and then to the other until the lamp lights or the voltmeter indicates. In this instance if the testing device is connected to *a* it will not indicate, but will indicate when connected to terminal *b*, the path of the current being indicated by the dotted lines and arrowheads.

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*If the voltmeter will read direct current only, connections t and t' will have to be interchanged before the instrument will read when connected to c.

After this has been determined the field coils may be tested for grounds by disconnecting the testing device from the frame of the machine and connecting it to one of the field terminals, as in Fig. 13, in which coil *B* is grounded at *x*. If no coils were grounded the testing device would not indicate. The grounded coil may then be located in the manner described for Figs. 9 and 10, or a voltmeter may be used in which case the wire *w* (Figs. 9 and 10) is dispensed with and the voltmeter lead is brought direct to one of the coil terminals as shown in Fig. 13.

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Plants of Interest in Milwaukee

By Thomas Wilson

SYNOPSIS—An unusually well illustrated article treating of features of plants in busy Milwaukee. An old Corliss engine installed in 1881 and giving service every day is described. The coal-handling plant for the Schlitz breweries is worthy of note.

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Of the manufacturing cities in this country, Milwaukee ranks as one of the foremost. It has a varied line of staple products, many of which are intended for use in the power plant. The city is one of the greatest coal distributing points on the Upper Lakes and its bank clearings are not far behind those of the great industrial centers. So much manufacture naturally requires a great deal of power, and, as might be expected, Milwaukee has a number of interesting plants; some are private installations, others belong to the three central-station companies, and in the breweries there are immense refrigerating plants which are worth investigating. It is the purpose of this article to enumerate the features of some of the leading plants, those that would be worth a visit while at the convention. Two of the large ones have been given space in this issue, and with those mentioned hereinafter there will be variety from which to choose.

Pfister & Vogel Turbine Plant

Perhaps the most pleasing looking installation in the city, and the simplest for its size, is the 3100-kw. turbine plant installed by the above company in 1910. The two large turbines, of the horizontal reaction type, are painted light gray and black, and with the copper piping the contrast is attractive. The latest instruments and gages, nicely mounted, also add to the appearance; their records show that a kilowatt-hour at the switchboard is produced for 1.05c. This includes operating expenses, interest and depreciation, with a load factor on both boilers and turbines of about 15 per cent. For coal alone the cost per unit is 0.38c. Barometric condensers serve the turbines, and to prevent clogging by the dirty water rom the Menominee River, special nozzles are so aranged that the openings are not restricted. A pressure of $\frac{3}{4}$ lb., or 1½ in. abs., is maintained in the condensers. The temperature of the water going to the hotwell is 90 deg., and to use it for industrial purposes in the tannery would save heating a fresh supply of water by live steam. To purify this very dirty water, however, one of the argest water softeners ever built, having a capacity of 50,000 gal. per hr., was placed in the plant. The water, eing hot, assists in the process of softening, and as the main tank is 72 ft. high, it is distributed by gravity to the departments. In summer, the water only loses 1 or 2 deg. in the softener but loses 3 or 4 deg. in winter.

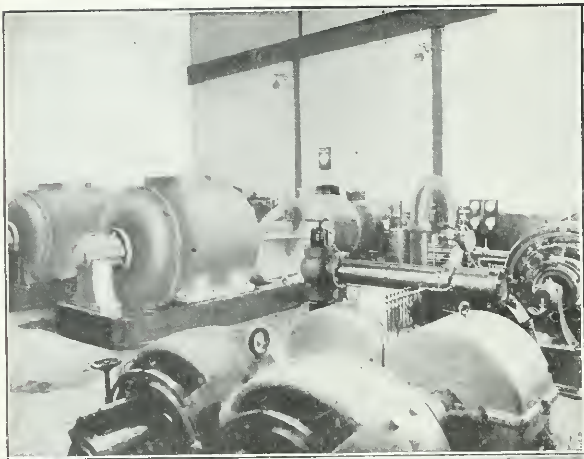
In the boiler room there are six water-tube boilers equipped with chain grates, a Darley pneumatic system of ash-handling and special facilities for getting the coal to the stoker hoppers. In the basement of the building containing the power plant there is a central hydraulic system for twelve elevators. The pump requires a 75-hp. motor, but 200 hp. or more would be required if individual electric elevators had been installed. In the basement of the new office building there is something of interest for the heating engineer—an air washer having a capacity to handle 40,000 cu.ft. of air per min. The air is blown into the rooms at 72 deg., and thermostatic control turns on direct radiation when the room temperatures drop below 70 deg.

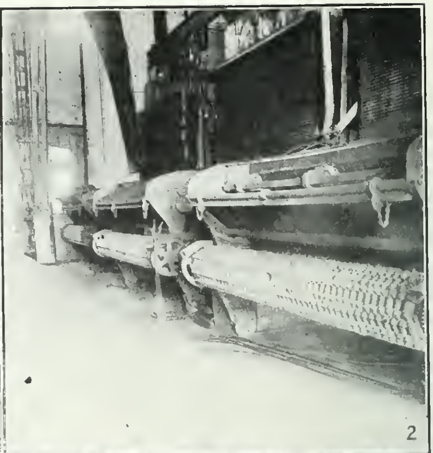
A Producer Gas-Engine Plant

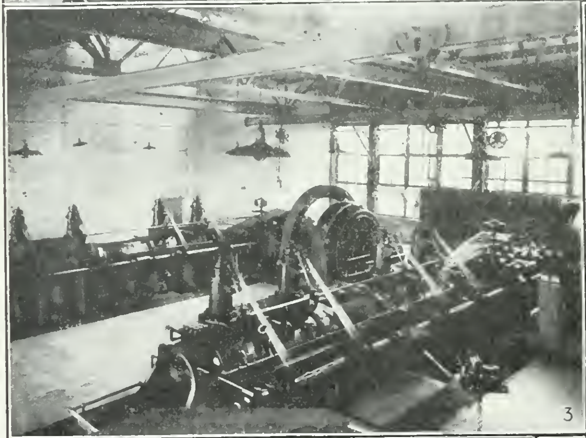
An 800-kw. producer gas-engine plant has been running without the slightest trouble for the past four years at the works of the A. O. Smith Co., makers of automobile parts, drop forgings and stampings. Soft coal is used in the producers and for the year 1913 the total cost per kilowatt-hour averaged 1.04c. This is made up of an operating cost of 0.634c. and a fixed charge of 0.47c. per unit. (See Power, of Mar. 10, 1914.) There are two 400-kw. tandem, double-acting engines, two 400-hp. pressure producers and two 350-hp. suction producers. The first two producers have rotary tar extractors and the others static tar extractors which latter were the second of their kind to be installed. (For further reference, this device was described in the Dec. 9, 1913, issue of Power.) The tar recovered is burned under heating boilers and per pound evaporates 9½ lb. of water. An interesting feature is the arrangement for utilizing the waste heat of the exhaust gases. The gas from the engines passes through a heater and then, in conjunction with waste gases from the annealing ovens, is delivered to hot-water heating boilers which are also equipped to burn either coal or tar. The engine jacket water which is passed through the heater is delivered to the boilers and any excess is sprayed and reused.

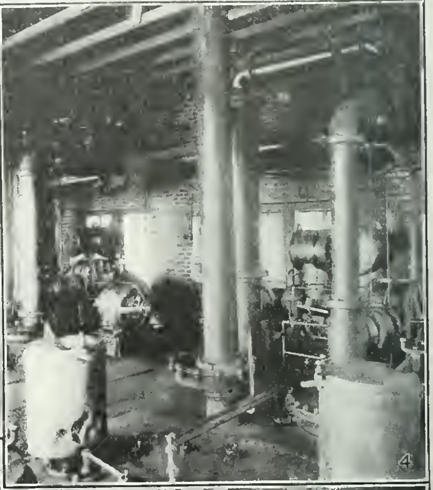
Central Stations

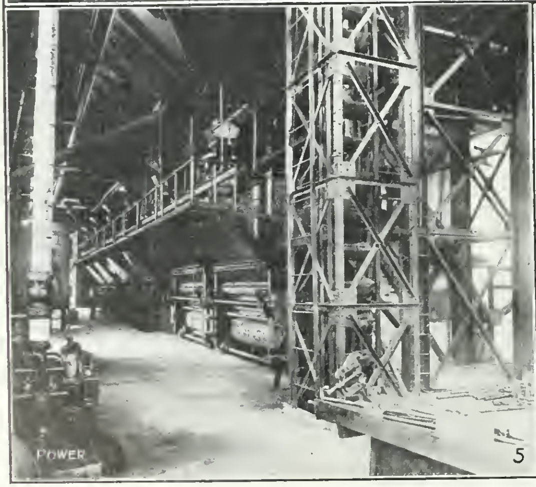
Of these there is quite a number. The Commerce Street station of the Milwaukee Electric Railway & Light Co. is described in a separate article in this issue.

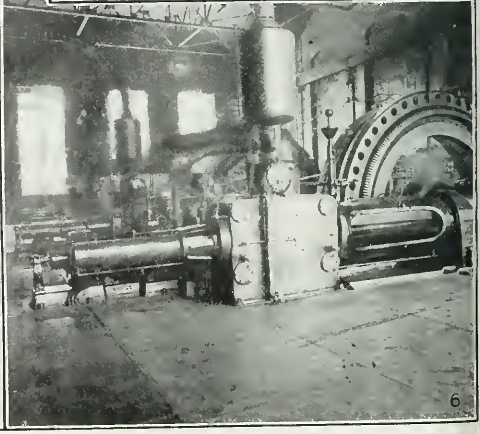












Views of Interesting Plants in Milwaukee

Fig. 1. Turbine room, Pfister & Vogel plant. Fig. 2. Pfister & Vogel Co.'s boiler room. Fig. 3. Gas engines, A. O. Smith Co.'s plant. Fig. 4. Top of gas producers, showing tar extractors, same plant. Fig. 5. Boiler room, Commonwealth Power Co. Fig. 6. Engines, Commonwealth Power Co.

The same company operates a plant on Oneida St. and another in the basement of the Public Service Building; both are run non-condensing and supply exhaust steam for heating. The Oneida St. plant, which supplies direct current only for railway and general service, has a capacity of 4750 kw. in five cross-compound vertical engine units and eight 500-hp. water-tube boilers equipped with underfeed stokers. Exhaust steam for heating is supplied to the business district east of the river and to a large area in the residence district, the connected load aggregating about 318,000 sq.ft. of radiation.

In the Public Service Building 60-cycle current at 4000 volts is generated. The main equipment consists of three 1500-kw. horizontal reaction turbines and ten 400-hp. water-tube boilers having underfeed stokers. The turbines are noncondensing and are run during the heating season to supply exhaust steam to the business district west of the river and a small part of the residence section. The lines consist of 1630 ft. of 16-in. pipe. 4460 ft. of 14-in. and 13,867 ft. of smaller pipe. The connected load is 170,000 sq.ft. of radiation.

The principal station of the Commonwealth Power Co. is also on Commerce St. It is a plant containing three cross-compound Corliss engine units served in common by a barometric condenser. A 3000-kw. reaction turbine and surface condenser are now being installed. There are six 500-hp., water-tube boilers with overhead bunkers and automatic scales to record the weight of the coal fed to the chain-grate stokers. Just above the station is the large coal yard of the Schlitz Brewing Co., with a storage capacity of 60,000 tons; it has two gantry cranes capable of unloading from a boat two tons per min. An 800-ft. belt carries the coal to the plant. As the clamshell buckets of the cranes are operated intermittently, the motors are supplied with 500-volt railway service from a 75-kw. motor-generator set which, to smooth out the irregularities in the demand, has a solid steel flywheel weighing 18,000 lb.

An Old Engine

At the John B. A. Kern & Sons flour mill, on the Milwaukee River between the two Commerce St. plants, is a Corliss engine which was installed in 1881. It has been on 24-hr. service, except Sundays, ever since, and is in excellent condition today. The engine is a tandem-compound, 28x56x48-in., developing at 65 r.p.m. a maximum output of 1000 hp. with steam at 125 lb. pressure. At the time of its erection it was the largest engine in the Northwest, and is said to be the first large machine built by Edwin Reynolds after his affiliation with the E. P. Allis Co. The original valve-gear is still intact. It is of the regular Reynolds type, but of heavier construction, as the solid wristplate will indicate. The usual flyball governor is belted to the main shaft and one eccentric operates the valve-gear of the two cylinders.

The engine has locomotive, or open, wrought-iron slides acting as braces from the housing of the low-pressure cylinder to the housing of the main shaft bearing. The bearing ends of the slides are fitted in slots and held by cross keys. An unusual feature is two piston rods between the low-pressure piston and the crosshead. The main connecting-rod has the old-style gib and key which has not been made for many years. The flywheel is 20 ft. in diameter and its 40-in. face is fitted with three belts, one over the other and leading to different floors. A jet condenser serves the engine. Two single-acting pumps, 16x20-in. driven by a double arm, remove the water and obviate the necessity of a foot valve. The shaft on which the double arm is mounted is rotated by a rockshaft, actuated through a connecting-rod by a reduced end on the crankpin.

The Garbage Incinerator

Killing two birds with one stone—that is, destroying its garbage and generating current for useful purposes—is what Milwaukee is doing with this interesting plant. Garbage is collected in the second story of the plant and fed downward into the furnaces. There are four independent units each having six fires and a capacity of 75 tons daily. The garbage is incinerated without the aid of fuel other than that found in the refuse matter. During the warmer weather better combustion is obtained by using cinders to separate the material. The gases from the destructor units are passed through 200-hp. water-tube boilers, of which there are four, although only three are used at any one time. With an evaporation of 1.25 lb. of water per pound of refuse there has been plenty of steam, but formerly most of it escaped to the atmosphere, only enough being used to generate current for the cranes, fans and lights. More recently, a generating station has been erected. It contains a 600-kw., single-stage, reaction turbine driving a three-phase, 4000-volt generator at 3600 r.p.m.; a Leblanc condenser serves the unit. Most of the current is transmitted to the Milwaukee River flushing station where the potential is reduced to 440 volts to serve a 350-hp. induction motor driving a centrifugal pump. The latter has a capacity of 21,000,000 gal. per hr. and during the day is supposed to replace the entire flow of the river. The station runs continuously six days a week and, besides the above load, lights McKinley Park and the bathing houses at McKinley Beach. At times, there is still steam to spare.

A Brewery Plant

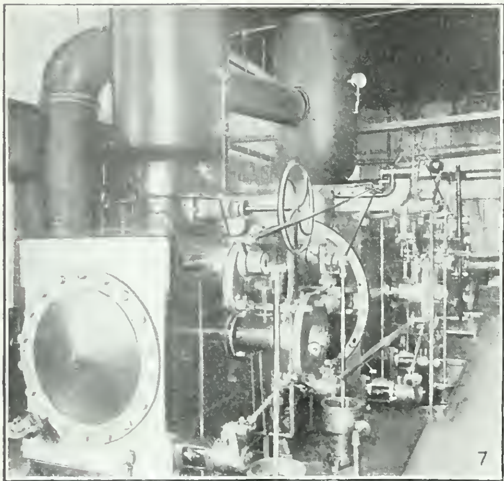
Those interested in refrigeration will naturally look to the large breweries, and of these Pabst is the nearest to the convention hall. In compressors there is a total capacity of 900 tons of refrigeration made up of two 300-ton, double-acting units and four 75-ton, single-acting machines, driven by Corliss engines. In the power plant there are two 400-kw., cross-compound vertical engines and one simple 300-kw. unit, all operating noncondensing and furnishing three-phase, 25-cycle current at 440 volts. From the simple unit steam is exhausted at 40-lb. pressure for cooking in the brewhouse.

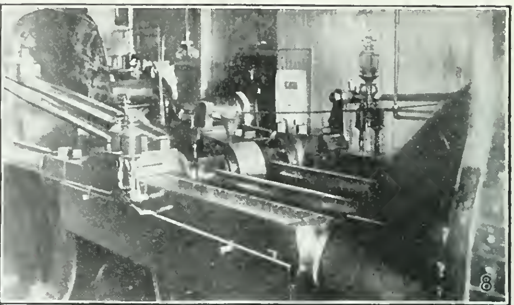
A new boiler room equipped with eight 400-hp. water-tube boilers, Murphy furnaces and economizers has replaced the one wrecked by the explosion five years ago.

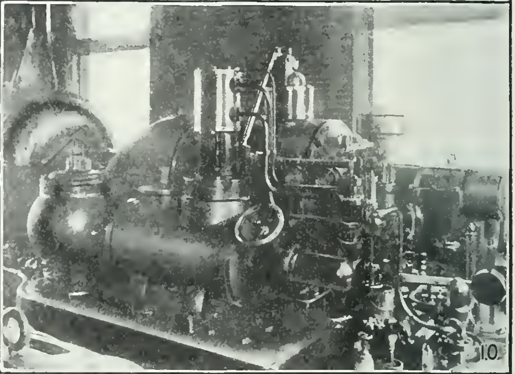
Coal is stored in individual overhead bunkers and weighed by hopper scales before reaching the furnace. It is delivered to the plant in a five-ton truck driven by worm gears instead of chains and having a hydraulic hoist. The truck has taken the place of four three-horse teams and one man operates it. Eighteen five-ton loads can be hauled in an 8-hr. day, the distance for the round trip being 3.4 miles.

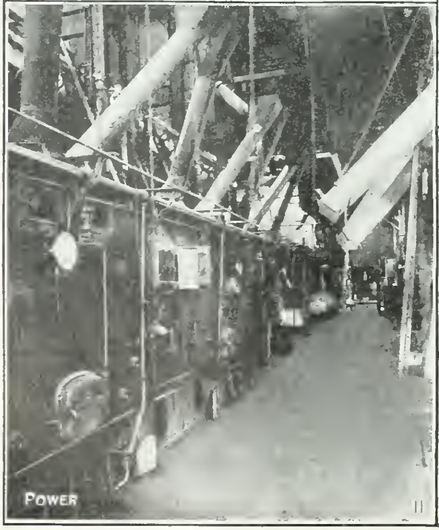
Coaling Plants

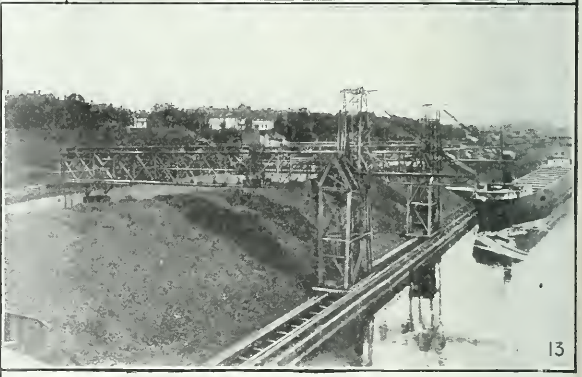
Milwaukee is called upon to care for more than 5,000,000 tons of coal in the comparatively short season of











More Views from Milwaukee Plants

Fig. 7. Old Corliss engine, Kern Flour Mills. Fig. 8. Crosshead and guides of the old Corliss. Fig. 9. Boiler room of the incinerator plant. Fig. 10. Turbine using steam from incinerator plant. Fig. 11. Boiler room of Pabst brewery. Fig. 13. Coal yard of the Milwaukee Western Fuel Co.

navigation. There are twenty-eight receiving plants along the various channels leading to the lake and all are equipped with the most modern appliances for handling coal. Their combined storage capacity is something like 4,000,000 tons and the equipment represents an unloading capacity of 100,000 tons every 10-hr. The Sixteenth St. yard of the Milwaukee Western Fuel Co. has two portable 8-ton man-trolley bridges and two portable steel towers, the outfit being capable of unloading 2000 tons per hour. A revolving bridge at the works of the Milwaukee Coke & Gas Co. is said to be the largest gantry crane ever constructed. It has a clear span of 360 ft., a cantilever extension of 120 ft. and carries a 5-ton

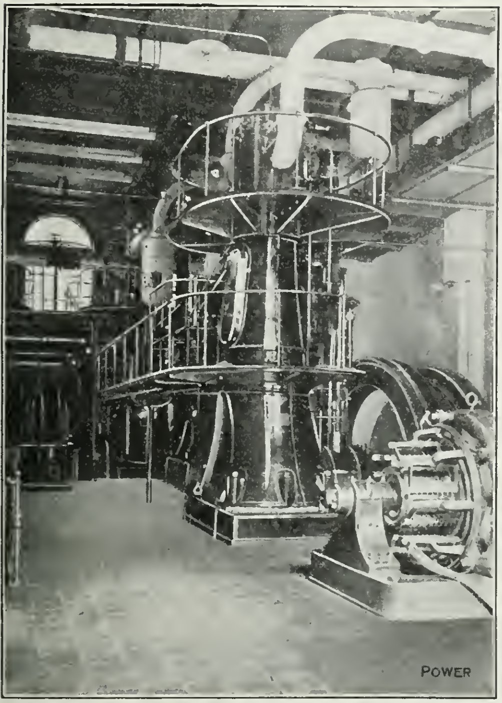


FIG. 12. VERTICAL ENGINES AT PABST BREWERY

bucket. Three fast hoists take coal from vessels at the rate of 300 tons per hour each, or a total of 900 tons. The plant was designed to handle 1,500,000 tons of coal over the dock in the course of a season. An interesting feature in the trade is the employment of two river barges equipped with elevating machinery to transfer the coal direct to bins or yards connected with power houses, thus avoiding a vast amount of teaming. The apparatus just referred to does not belong to the power plant, but it is handling a product familiar to all and in a way that is most interesting.

There are other plants in Milwaukee which are well worth a visit. At the public library the engineer keeps a most complete system of records, and the same is true at the plant of the Falk Co., which is producing current at an average cost of 1c. per kw.-hr. Then there are the manufacturing establishments turning out power plant products. A general knowledge of the finished article should create an interest to see how it is made and assembled.

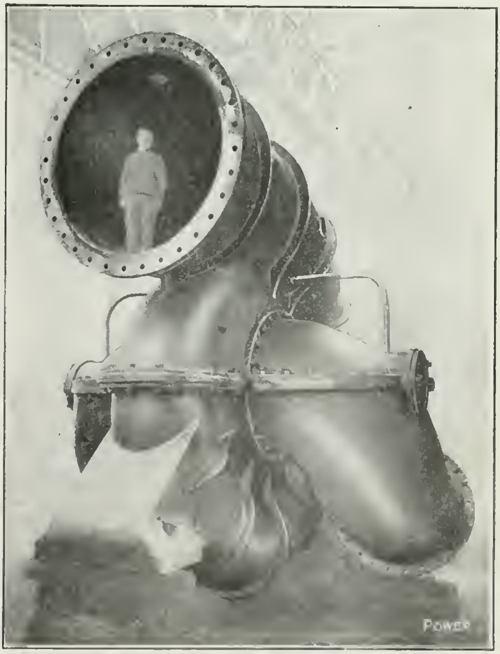
A visit to any of the following plants would not be regretted: Allis-Chalmers Co., Avery Scale Co., Bayley Manufacturing Co., Chain Belt Co., Cutler-Hammer Manufacturing Co., Filer & Stowell Co., H. W. Johns-Manville Co., Nordberg Manufacturing Co., Pawling & Harnischfeger and the Vilter Manufacturing Co.

Another feature which may be of interest is the new experimental power plant just installed by the Central Continuation School, a public institution maintained by the city of Milwaukee to offer educational facilities for the workers. The Board of Industrial Education equipped the plant as a result of a petition of Wisconsin No. 1, N.A.S.E.

*

Largest Centrifugal Pumps Yet Built

The pump of which the photograph is reproduced herewith is one of five which are being built by the Southwark Foundry & Machine Co. for the Plaquemine & Jefferson Drainage District of Louisiana. Four of these pumps have 76-in. outlets and the fifth a 48-in. outlet. Their function is to pump water back over the levee into the Mississippi River for the purpose of draining a district near the Plaquemine Canal. The large pumps have a lift varying from 1 to 13 ft. and the smaller pump from 3 to 8 ft. The capacity is 168,000 gal. per min. at 1 ft. head, and 40,000 gal. per min. at 13 ft. head for the larger pumps; 47,500 at 3 ft. head, and 40,000 at 8 ft. head for the smaller pump. The usual head will be from 3 to 6 ft. The pumps are to be driven by compound condensing Nordberg Corliss engines, designed for 170-lb. gage initial pressure and 25½ in. of vacuum, and it is expected that a duty of about 95,000,000 ft.-lb. per 1000 lb. of steam will be obtained with the larger, and 85,000,000 with the smaller pump.



76-IN. CENTRIFUGAL PUMP FOR PLAQUEMINE DRAINAGE PROJECT

*

The Word "Zero" is from the Spanish, and means empty, hence nothing. It was first used for the thermometer in 1795 by the Prussian merchant and physicist Fahrenheit.

Massachusetts Boiler Law and Rules--II

By C. O. Andrews

SYNOPSIS—Continuing the discussion of the rules drawn by the Massachusetts Board of Boiler Rules, this installment deals with those included in Part III.

⁂

PART III—SECTION 1

Since part three applies only to boilers to be installed after the passage of the law, the greatest latitude was allowed in making the rules, for they could not affect the property rights of anyone.

Section 1 deals with the chemical and physical qualities of the materials to be used in boilers and how such qualities are to be ascertained. Some steel manufacturers have objected to the chemical qualities called for by the rules, but the requirements are apparently none too stringent and can be easily met by the manufacturer of good boiler plate.

The physical qualities could be changed to advantage from every viewpoint. The present scheme of fixing pressures induces the boiler manufacturer to secure plate of as high tensile strength as possible and keep within the limit prescribed by the rules (62,000 lb. per sq.in.). This means that the plate will come between 57,000 and 62,000 lb. tensile strength per square inch. While the rules no doubt intended having the average tensile strength about 57,000 lb., the plate actually being used probably ranges around 60,000 lb. Steel manufacturers and nearly all authorities acknowledge that material of 50,000 or 52,000 lb. per sq.in., would be better and that boilers constructed of it would stand the same presure for a given thickness more safely.

Preferably, a range of tensile strength from 50,000 to 60,000 lb. should be required and the pressure allowed on the lowest tensile strength, or on the average tensile strength of the range, fixed without reference to the actual tested strength of the material.

No comments are offered in connection with the rest of this section; the various paragraphs follow the standards prescribed by the American Society for Testing Materials and have been in common use for a long time.

SECTION 2

Paragraphs 4 and 5, which deal with the tensile strength of cast steel and cast iron to be used for superheaters and also for boiler attachments, specifying the values required but not how the test pieces are to be obtained; instructions on this point are necessary to be certain of results. Limiting the pressure on boilers, the headers, drums or other parts of which are made of cast iron, to 150 lb. as specified in *paragraphs 6 and 7*, is wise.

Paragraphs 10 and 11 specify that water-leg and door-frame rings for locomotive and vertical fire-tube boilers must be wrought or cast steel. As there is no danger from using cast iron for such parts these paragraphs seem superfluous.

SECTION 3

Paragraph 2 of this section deals with the stamping of boilers at the place of manufacture; some provision should be made for correcting improperly stamped boilers when an error has been made by the stamper. Simple mistakes in stamping have brought inspectors and the representatives of boiler manufacturers long distances, merely to change the location of a letter or to change a number on the stamp.

Paragraph 5 concerns the location of stamps on boilers of various types. The rule is well arranged, but could be improved in two respects. Under item (c) the location of stamps for locomotive and Star water-tube boilers is designated as on the furnace end and above the handhole.

These boilers may have more than one handhole on the firebox end, and then the boilermaker does not know over which one to place the stamp. It would be better if the location had been given as above the fire-door and about on a line with the crown sheet and above the handhole, if one should be located at this point.

Under (d) the location for the stamping is designated for vertical tubular and submerged tubular boilers, as on the sheet above the furnace door. The same suggestion as before would apply in this case, and the instructions would apply equally well to any of the types mentioned. The reason for stamping above a handhole is that leakage is liable to corrode the plate below it and obliterate the stamp.

SECTION 4

Section 4 is extremely long and deals with many parts of boiler construction. *Paragraphs 1, 2 and 3* deal with the calculation of the shells of drums which are pierced by tube holes, and the same criticism seems to apply as to the methods to be used in calculating the efficiency of riveted joints. The mere statement that the strength of the ligament between the tube holes must be taken into account in calculating the strength of such drums would be sufficient, as far as the rule is concerned. The detailed description of how to determine the efficiency of the tube ligaments, should be given in an appendix. The instructions in the ease of staggered holes, while not mathematically correct, are near enough for all practical purposes and avoid involved calculation.

Paragraph 4 deals with staying heads of small boilers for pressures of 100 lb. or less, with angle-iron stiffeners. Most of this matter preferably should be in an appendix. The strength of only the outstanding leg of the angle is considered in the calculations. This is justified, since it is on the side of safety and simplifies the calculation. One of the most important features in connection with angle-iron stiffeners has been omitted, i.e., how the ends of the angles should come, in relation to the turn of the flange on the head.

Lengths are given for angles to be used for bracing the heads of boilers 30 and 36 in. in diameter, but these dimensions would not answer for a 26-in. or 34-in. head. It would be better to state the maximum fiber stress to be allowed on the supporting members and that they must come well up on the turn of the flange of the head to be supported; or better still, to specify the size and number of angles to be used on each side of the boiler and the approximate spacing of the rivets to attach the angles to the heads. Since the maximum pressure to be used on boilers braced in this manner is limited to 100 lb. and the range of sizes to be covered is small, no difficulty should be experienced in treating the subject in this manner and it would remove the necessity of placing in the book beam formulas which are not and need not be understood by the average inspector.

Paragraphs 5 and 6 deal with longitudinal joints and specify that on boiler shells exceeding 36 in. in diameter, they must be of the double-butt strapped type, and on boilers 36 in. or less in diameter, for pressures not exceeding 100 lb. the lap joint may be used. These provisions are all good, but a higher factor of safety should be required on boilers having lap joints. The fact that the diameter of the boilers is small, does not prevent the formation of lap-joint cracks, in fact, a small cylinder is more likely to be out of true at the seams than a large one.

Probably there are not more explosions due to lap cracks, on small-diameter boilers, on account of the short courses producing a stiffer structure. An increase in the safety factor would likewise insure a structure of greater stiffness. Limiting the pressure on lap-seam boilers to 100 lb. is not enough safeguard for some of the most disastrous explosions have occurred at pressures below this. It might be thought that elimination of the lap seam would remove all questions, but such a course could hardly be justified. Placing double-butt strapped joints on cylinders of small diameter is sometimes difficult if not impractical and the facilities for fitting in some shops are such that the lap seam is probably more reliable than a seam of the butted and double-strapped type.

Paragraph 9 states that horizontal return-tubular, vertical tubular and locomotive boilers, cannot have a continuous longitudinal seam over 12 ft. long. Long longitudinal seams on these types would not be more dangerous than on other boilers. This limitation was probably an attempt to avoid interference with the standard construction of some types of water-tube boilers, but if regarded as a menace to safety, long seams should have been prohibited on all types, since the rules in this part refer only to boilers to be installed after the passage of the law.

Paragraph 10 requires that the thickness of the plates in the shells of drums be of the same gage. This does not seem a necessary rule for safety and interferes with at least one standard make of water-tube boiler.

Paragraphs 11 and 12 give the minimum thicknesses of plates to be used in boilers. This is a good rule for it is necessary to prescribe such limits, i.e., the shells must be at least $\frac{1}{4}$ in. thick and for diameters over 36 in. and including 54 in., the thickness must be at least $\frac{5}{16}$ in., above 54 in. and including 72 in., the shell must be $\frac{3}{8}$ in., and for all diameters over 72 in., the shell must be at least $\frac{1}{2}$ in. This range of minimum thickness is conservative and regardless of the pressure to be carried, no boiler should be built of material of less thickness than specified.

Paragraph 14 states that butt straps are to be rolled or formed to the proper curvature, on forms made for the purpose. While this is important, it is much more so that the ends of the shell sheets, where the longitudinal seams are to come, be properly formed. Nothing in the rules states how the ends of the sheets at the joint are to be formed. Usually the rivet holes are punched for the longitudinal seam and then the plate is placed between the rolls (turned in the opposite direction from the one in which it is intended to be rolled), the plate is then sledged down over the bottom roll along the line of the longitudinal seam. This seriously injures the metal and should be prohibited. It should be required that the ends of the plate be formed under a press to the proper curvature. While a hydraulic press is preferable, the work could be done properly under a screw press, hence the equipment cost would not be unreasonable for any boiler manufacturer.

Paragraph 15 on the minimum thickness of tube sheets, is good, but this thickness should depend on the tube diameter as well as the boiler diameter. A rule should prescribe the minimum space to be allowed between the tube holes for given thicknesses of tube sheets and diameters of tubes.

Paragraph 16 determines the thickness for bumped heads and copies the old Government rule on the same subject. The formula given is based on the assumption that a portion of a sphere cut off and attached to the end of a cylinder will behave as if it were still part of the original sphere. Practice has proved this is a fallacy and a new rule should be made to establish the thickness for bumped heads.

Paragraph 21, giving a table of maximum pitches to be allowed for staybolts in the formula, is too conservative for the spacing could be increased safely. The latter part of this paragraph states that, when hollow stays are used having holes $\frac{1}{2}$ in. or over in diameter, the pitch of the bolts may be increased by the mean diameter of the bolts. This rule was without doubt made to avoid conflict with the construction of some of the existing types of water-tube boilers. While, with a given thickness of sheet, larger staybolts could be safely spaced farther apart, as far as the strength of the sheet is concerned, the size of the hole in the bolt could have no influence on the proper spacing. Some water-tube boilers have hand holes cut in one of the stayed members and tube holes in the other, and it has been demonstrated that the rules are over-conservative as applied to such construction. A logical rule to cover the situation, would be better than an arbitrary one without reason.

Paragraph 22 gives an arbitrary rule for the staying of internal furnaces of not over 38 in. diameter, intended for the furnaces of small vertical tubular boilers and is without doubt safe, but it is inconsistent, in that the holding power of the staybolts is to be depended on considerably and the minimum thickness of furnace plates is not made to correspond to those given in *paragraph 19,* where $\frac{5}{16}$ in. is the minimum.

The rules are not complete with respect to furnaces, for they give no formula to determine the strength of Morrison or other types of self-supporting furnaces.

Paragraph 28 explicitly explains how to figure the area to be stayed on the heads of horizontal tubular boilers, and the table in *paragraph 29* gives the areas to be stayed on boilers of various diameters with segments of varying height. This table is well arranged and saves boiler inspectors and manufacturers much work besides tending to eliminate mistakes.

The formula in *paragraph 30,* for determining the area to be stayed, when not given in the table, is simple and sufficiently accurate for practical use. A defect in the law is the failure to fix pressures for unbraced boiler heads. Many boilers in the state do not comply with the law as it now reads and the inspection department has been compelled to overlook violations. Since no provisions have been made, segments over 5 in. high would have to be braced to comply strictly with the rules, this 5 in. being made up of the 2-in. allowance from the tubes and the 3-in. space from the shell of the boiler.

Many horizontal return-tubular boilers, of considerable size, have greater distances from the tubes to the shell at the side of the boiler than would be allowed by a limit of 5 in. and braces on such surfaces would decrease the safety of the boiler. Boilers of other types also necessarily violate this part of the rules. Provision should be made to permit a reasonable pressure on the segment of a head, or on a round head, without requiring braces; a formula similar to Nicholls' Rule would answer.

Paragraph 31 specifies that where a man-hole opening is flanged in, to a depth of twice the thickness of the head, an area 2 in. wide all around the man-hole opening may be deducted from the total area to be braced. This rule does not seem to be logical for cutting a manhole in the head of a large boiler cannot change the amount of bracing required to safely support the head.

Paragraph 32 is not clear as to how the bracing is to be attached to the rear head of the boiler. The rule states that the rear ends of the braces are to be attached to the rear head of the boiler, but it is not feasible to attach these ends except through crowfeet or similar devices, the questions arise as to how far apart the rivets shall be spaced and also whether the spacing of the braces or of the rivets which attach them to the head must conform to the spacing required for staybolts on flat surfaces. It is not practical to space braces the same as stays, although the surfaces supported must be considered stayed surfaces. Some rule should be adopted which would overcome this difficulty.

In *paragraph 35*, devoted to the stress per square inch allowable on different kinds of stays and staybolts, unreasonable variations are allowed. The values closely follow such allowances as are given in the Steamboat Inspection Rules. There is no reason why a large diameter brace should be allowed a higher stress than one of small diameter. The smaller brace, exposing relatively greater surface, will deteriorate more rapidly, but this does not warrant the difference allowed, especially as the material of the smaller brace is somewhat stronger than that of the larger one. The values for allowable stresses on braces are probably too conservative. Those given for the larger braces would no doubt be perfectly safe for braces of all sizes.

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Pittsburgh Smoke Ordinance—A new ordinance has been passed in Pittsburgh, the enforcement of which hinges upon the use of the Ringlemann chart. The new measure provides penalties—fines of from $10 to $100, or imprisonment from 5 to 30 days, for each violation—for the production of smoke equal to or greater in density than scale 3 on the chart. The restrictions read as follows: "The production or emission within the city of smoke, the density or shade of which is equal to or greater than No. 3 of the Ringlemann chart, from any stack, except that of a locomotive or steamboat, for a period or for periods aggregating two minutes or more in any period of 15 min., and the emission of such smoke from any locomotive or steamboat for a period or periods aggregating one minute or more in any period of eight minutes, except for a period not to exceed 20 consecutive minutes, not to exceed once a day, while a new fire is being built therein, is hereby prohibited."

Universal Handhole Scraper

A scraper to be used on the countersunk gasket seat of the handholes in the forged-steel water legs of high-pressure water-tube boilers is shown in Figs. 1 and 2.

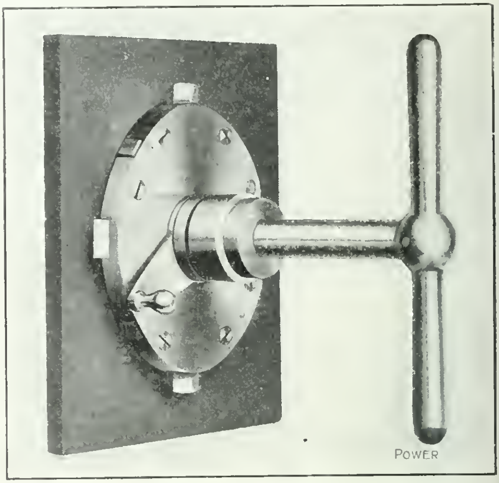

FIG. 1. FRONT OF THE HANDHOLE SCRAPER

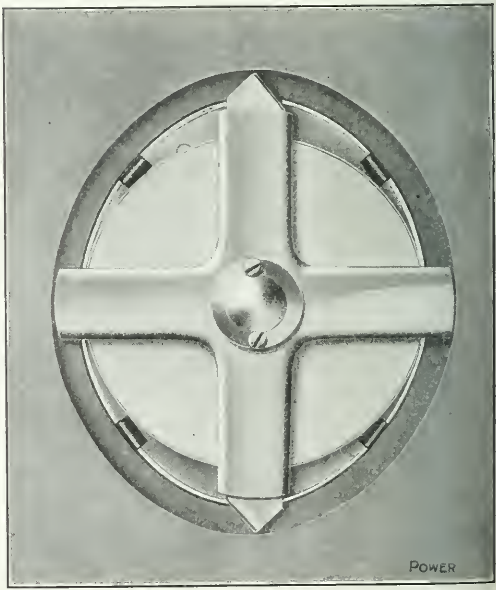

FIG. 2. BACK OF THE SCRAPER

The tool will clean the gasket seat perfectly in from six to ten seconds. It is inserted in the handhole, just as a plate would be, and the little lever on the left is moved downward until the clutching blades take hold and fasten the tool firmly in the hole. These blades have beveled ends grooved to prevent them from slipping and allow the body of the tool to teeter while in operation.

The beveled ends cause the scraping blades to be pressed evenly against the gasket seat. As the tool is turned in the hole, it becomes loose or relaxed. This means that the gasket seat has been partially cleaned, and it is necessary to move the chucking lever farther downward. If necessary, this movement is repeated a third time, as the tool is revolved in the hole, and when the lever has been moved to the stopping point downward and the tool turns easily, it will be known that the gasket seat is clean. Under ordinary conditions, five or six turns of the scraper to the right will be sufficient.

There is a coiled impression spring in the collar of the tool, shown just above the body, which regulates the pressure of the scraping blades on the gasket seat. These blades are so constructed that they have a "lead" or shearing movement over the gasket seat, which tends to prevent chattering.

The four flat springs shown on the outer edge are for centering the tool. The spider carrying the scraping blades is so fastened to the handle that movement similar to a universal joint is obtained. This assures an even seating of the blades upon the gasket seat. There is a thin, spring-acting disk between the spider and the body of the tool which keeps the dirt and scrapings out of the working parts, as well as permitting an automatic takeup for wear on the blades. The tool is made by the Universal Handhole Scraper Co., 326 West Madison St., Chicago.

⁂

Hand-Fired Furnace for Water-Tube Boilers—II*

By Osborn Monnett†

SYNOPSIS—Typical designs of semi-extension furnaces for horizontal water-tube boilers burning wood refuse, for horizontal boilers vertically baffled and for vertical boilers.

⁂

Semi-Extension Furnaces

With boilers having 16-ft. tubes where it is desired to burn a large amount of wood refuse, it is difficult to install a hand-fired furnace which will give a satisfactory atio of grate surface to heating surface, for the reaon that when the furnace is installed it will be found hat the opening into the bank of tubes is restricted. It s desirable here to install a semi-extension, dutch-oven urnace which will dispose of an enormous quantity of ood refuse and allow a large grate surface to be intalled where large capacities must be obtained from he equipment. This type of furnace is especially derable where the wood refuse is wet as it gives an igniting effect not obtained in the flush-front settings shown in the last article. It is not advisable, however, to use this setting where any considerable quantity of coal is to be burned, as almost invariably the setting will smoke when burning coal alone.

Fig. 7 shows a semi-extension furnace with a deflection arch, adapted to an Atlas boiler. In this particular setting it was found that with box tile over the bridge-wall the temperature was too high for good results, so that half of the box tile was removed, leaving the tube surface in the front half of this zone bare to the fire. This had a steadying effect on the water level in the boiler and increased heat absorption with a corresponding decrease in the temperature of the brickwork. A deflection arch in two spans is installed 36 in. behind the bridge-wall and two 13-in. piers are placed on the bridge-wall opposite the spans in the arches. The gas passes through the bank of tubes in three sweeps, as will be apparent in the drawing, passing thence along the superheating tubes to the uptake. This setting is for a 250-hp. boiler and

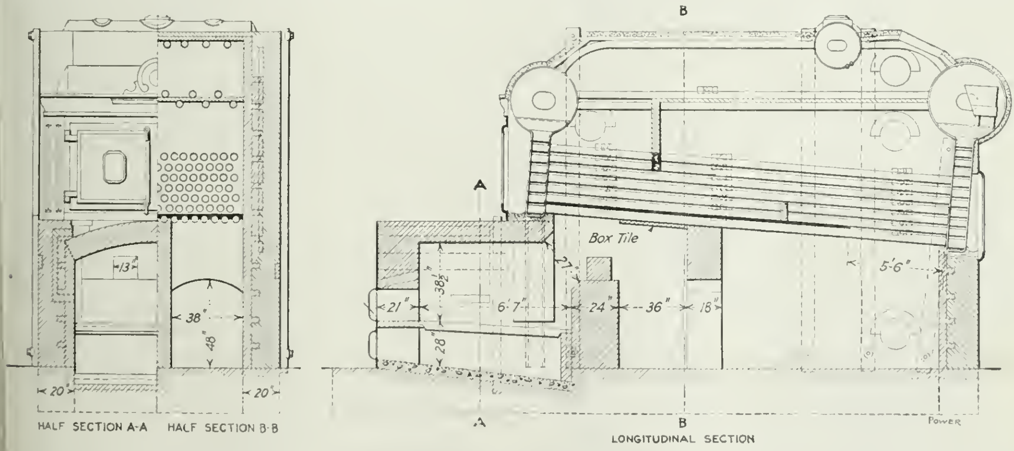

Fig. 7. Semi-Extension Furnace under Atlas Water-Tube Boiler

the extension from the front header measures 6 ft. over all.

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*Copyrighted, 1914, by Osborn Monnett.

†Smoke Inspector, City of Chicago.

Fig. 8 shows another semi-extension dutch-oven furnace for burning wood refuse exclusively. All essential dimensions of the setting are shown on the drawing. In this case the box tile is carried completely over the bridge-wall and the gas pass is of the standard Heine type. It will be noticed that the height from the floor line to the front header is 7 ft. and that the chute feeds through the top of the arch. Also, the grates are pitched 12 in. at the bridge-wall, giving an unusually high bridge-wall and causing the gases to pass upward against the box tile before being directed against the deflection arch. This tends to prevent smoke formation as the gases and the air are thoroughly mixed.

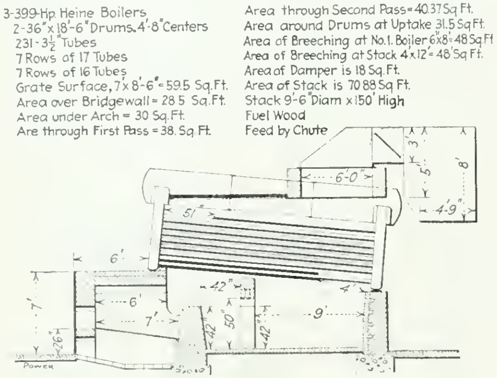

3-399-Hp. Heine Boilers
2-36"x18'-6" Drums, 4'-8" Centers
231-3½" Tubes
7 Rows of 17 Tubes
7 Rows of 16 Tubes
Grate Surface, 7'x8'-6"=59.5 Sq. Ft.
Area over Bridgewall=28.5 Sq. Ft.
Area under Arch=30 Sq. Ft.
Are through First Pass=38. Sq. Ft.
Area through Second Pass=40.37 Sq. Ft.
Area around Drums at Uptake 31.5 Sq. Ft.
Area of Breeching at No. 1 Boiler 6'x8'=48 Sq. Ft.
Area of Breeching at Stack 4'x12'=48 Sq. Ft.
Area of Damper is 18 Sq. Ft.
Area of Stack is 70.88 Sq. Ft.
Stack 9'-6" Diam x 150' High
Fuel Wood
Feed by Chute
6'-0"
3'
5'
8'
4'-9"
51'
6'
7'
6'
7'
42"
50"
42"
42"
9'
4'
26"
POWER

FIG. 8. HEINE BOILER WITH SEMI-EXTENSION WOOD-BURNING FURNACE

Fig. 9 shows another semi-extension setting in which the bridge-wall is set a considerable distance under the boiler and the extension is brought down to a minimum. This construction decreases the floor space occupied and lowers the first cost as well as the maintenance. The boiler is of the Babcock & Wilcox type and is provided with Sewell baffling. It is only 6 ft. 6 in. from the bottom of the front header to the floor line. To get the proper areas it was necessary to excavate in the combustion chamber.

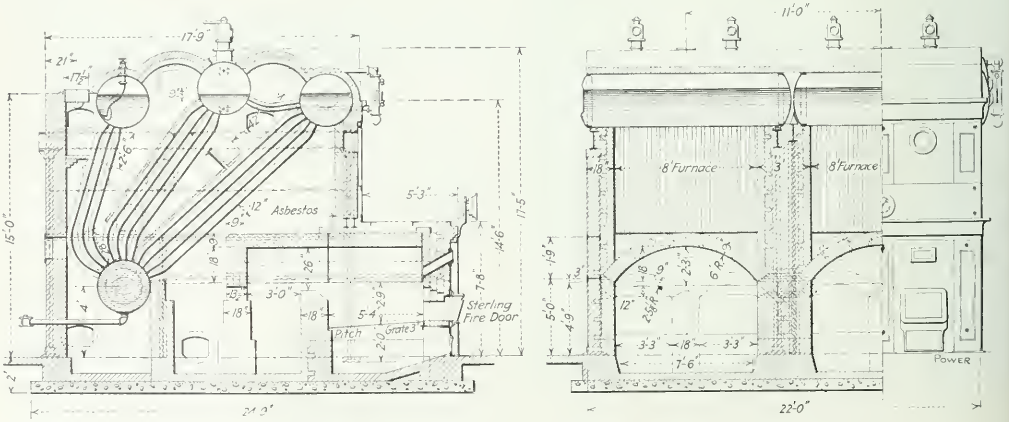


FIG. 10. STIRLING BOILER WITH HAND-FIRED DUTCH-OVEN FURNACE

One of the most important considerations in operating these furnaces is air admission. Shavings must be supplied with large volumes of air from the top if they are to be consumed without smoke, so that special attention must be given to the admission of air through the panels after firing. If the fuel is fed with scoops it is frequently necessary to run with the doors practically wide open, where the fire is charged frequently, as it is impossible to get sufficient air through the grates to consume the fuel without smoke.

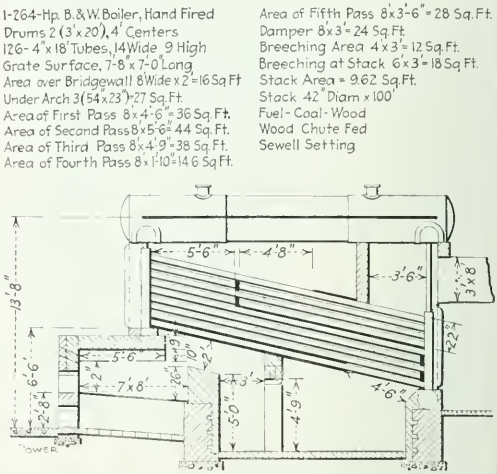

1-264-Hp. B.&W. Boiler, Hand Fired
Drums 2 (3'x20'), 4' Centers
126-4"x18' Tubes, 14 Wide 9 High
Grate Surface, 7'-8"x7'-0" Long
Area over Bridgewall 8' Wide x 2'=16 Sq Ft
Under Arch 3(54"x23")=27 Sq. Ft.
Area of First Pass 8'x4'-6"=36 Sq. Ft.
Area of Second Pass 8'x5'-6"=44 Sq. Ft.
Area of Third Pass 8'x4'-9"=38 Sq. Ft.
Area of Fourth Pass 8'x1'-10"=14.6 Sq Ft.
Area of Fifth Pass 8'x3'-6"=28 Sq. Ft.
Damper 8'x3'=24 Sq. Ft.
Breeching Area 4'x3'=12 Sq. Ft.
Breeching at Stack 6'x3'=18 Sq. Ft.
Stack Area = 9.62 Sq. Ft.
Stack 42" Diam x 100'
Fuel-Coal-Wood
Wood Chute Fed
Sewell Setting
5'-6"
4'-8"
3'-6"
3'x8'
13'-8"
22"
5'-6"
7'x8'
6'-6"
2'-8"
2'
26"
10"
3'
5'-0"
4'-9"
4'-6"
POWER

FIG. 9. B. & W. BOILER WITH SEWALL BAFFLE AND REFUSE-BURNING FURNACE

Where the fuel is chute fed the excess air being discharged through the blower system aids materially in running smokelessly. However, there will be times when the furnace will be practically full of fuel, and at such times it will be necessary to open the doors wide. Where the quantity of fuel is excessive it has in one or two instances been found advantageous to make a couple of square openings in the top arch near the front of the furnace through which excess air is supplied at all times. This expedient has been applied with success to some chronic smokers burning wood refuse. These unusual measures may seem to be inadvisable from the standpoint of economy, but where smoke is a prime consideration, it may be sometimes necessary to adopt them, as wood refuse and shavings form one of the most difficult fuels to burn smokelessly.

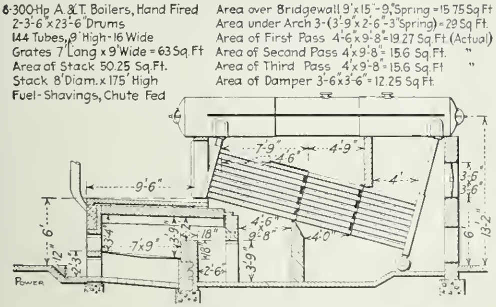

8-300-Hp A.&T. Boilers, Hand Fired
2-3'-6"x23'-6" Drums
144 Tubes, 9' High-16 Wide
Grates 7' Long x 9' Wide = 63 Sq.Ft
Area of Stack 50.25 Sq.Ft.
Stack 8' Diam. x 175' High
Fuel-Shavings, Chute Fed
Area over Bridgewall 9'x15'-9," Spring = 15.75 Sq Ft
Area under Arch 3-(3'-9"x2'-6"-3" Spring) = 29 Sq Ft.
Area of First Pass 4'-6"x9'-8" = 19.27 Sq.Ft. (Actual)
Area of Second Pass 4'x9'-8" = 15.6 Sq.Ft. "
Area of Third Pass 4'x9'-8" = 15.6 Sq.Ft "
Area of Damper 3'-6"x3'-6" = 12.25 Sq Ft.
7'-9"
4'-6"
4'-9"
9'-6"
4'
3'-6"
3'-6"
13'-2"
6'
6'
7'x9"
18"
4'-6"
9'-8"
4'-0"
2'-6"
3'-9"
Power

FIG. 11. AULTMAN & TAYLOR BOILER VERTICALLY PASSED AND EQUIPPED WITH WOOD-REFUSE-BURNING FURNACE

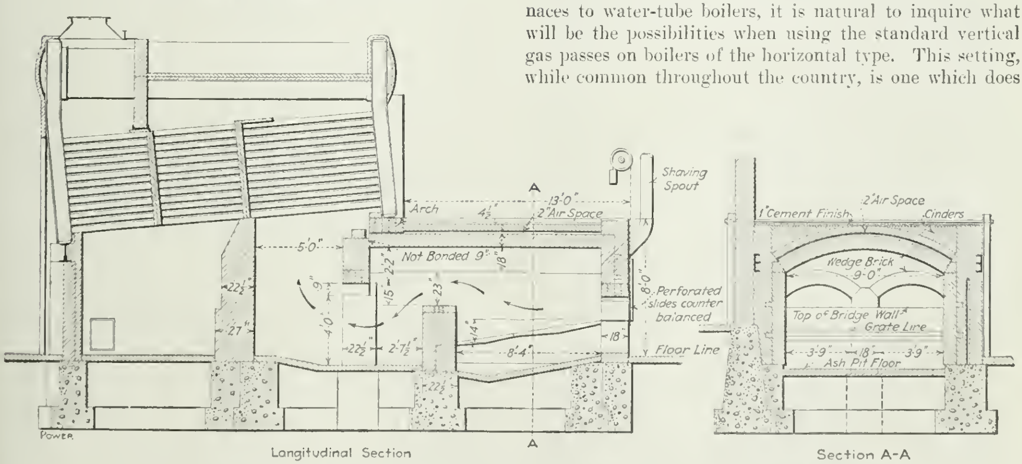


FIG. 12. EDGE MOOR VERTICALLY PASSED BOILER WITH WOOD-REFUSE-BURNING FURNACE

On the other hand, it must be admitted that this fuel is only a waste product in any event, and if the efficiency falls off a trifle, due to excess air, the actual financial loss is slight. As a matter of fact, the capacities can be high provided the draft is sufficient. A 500-hp. boiler using a furnace similar to the foregoing has been run continuously at 800 hp. without smoke.

When designing a wood-refuse-burning furnace it is of importance to know approximately at what capacity the unit will be run. If the capacity goes up over 150 per cent. of rating, it will be necessary to supply more area between the back of the bridge-wall and the deflection arch to take care of the large volume of gases passing this point. This will also increase the life of the brickwork. The ordinary ratios of gas passes to grate surface previously given will hold up to 150 per cent. of rating. Above this, increase them proportionately.

VERTICAL BOILERS

Fig. 10 shows a typical furnace for a Stirling or any other boiler which does not lend itself to the horizontal gas pass, such as the Erie City vertical, the Milne, Hogan, Rust, Wickes vertical, etc. The unit is rated at 185 hp. The extension is 5 ft. 3 in. and the height of the dutch oven 7 ft. 8 in. The ratio of grate to heating surface is 1 to 45. The deflection arch is made in two spans.

It is easy to make a mistake in a setting of this type. If any restriction occurs in the baffling of the tubes, under the deflection arch, or in the zone back of the bridge-wall, or if the stack is not of sufficient height to give ample draft, the heat will be "bottled" in the furnace and radiated out into the boiler room; the brickwork will not stand the temperature and the capacity will not be obtained.

The best coal to burn in this furnace is a clean 3x6-in. egg, as it takes longer to distill the gas out of coal of this size. A smaller coal that gives up its volatile too rapidly would not be satisfactory, owing to the intense heat forcing the gas out in puffs that could not be controlled.

HORIZONTAL BOILERS VERTICALLY PASSED

When speaking of the application of hand-fired furnaces to water-tube boilers, it is natural to inquire what will be the possibilities when using the standard vertical gas passes on boilers of the horizontal type. This setting, while common throughout the country, is one which does not lend itself to smokeless operation. The flame travel is short and the dampening effect of the tubes in the first pass is such that complete combustion is not obtained. Moreover, it is practically impossible to modify the hand-fired type of furnace using the vertical pass and get a satisfactory installation from all standpoints. The ordinary dutch-oven furnace as applied to the vertical-pass boiler does not provide sufficient flame travel and gas mixture to be considered successful under a strict smoke ordinance. If the dutch oven is extended sufficiently to get flame travel and deflection, the installation becomes unwieldly and expensive from the standpoint of floor space occupied, first cost and maintenance. For the ordinary power load when burning coal, it has been found practically impossible to use this kind of baffling with hand-fired furnaces.

There have been a few chute-fed wood-refuse furnaces installed in connection with the vertical baffle which are giving good results, but ordinarily such an installation could only be made when building new and where floor space is unlimited. Fig. 11 shows this kind of a furnace which is run at high capacity and is satisfactory from the smoke standpoint; the maintenance item, however, is high. The setting is applied to a 300-hp. Aultman & Taylor boiler and the total extension is 9 ft. 6 in. from the front flue caps. The floor was excavated considerably to get the furnace in under the front header and the deflection arch was installed as in the original design of hand-fired furnaces. The deflection arch is in two spans and there is ample space between the deflection arch and the first baffle wall for the gases to enter the heating surface. The furnace is chute fed and burns shavings with success up to a rate of 120 lb. per sq.ft. of grate surface per hour. The furnace could not be recommended for the use of coal exclusively.

Another setting with a 13-ft. extension applied to an Edge Moor boiler is shown in Fig. 12. This was installed new, and ample floor space was provided for the furnaces as well as head room under the front header. The firing doors are suspended by counterweights and offer ample provision for admitting excess air in times of emergency. Such furnaces when properly handled will run smokelessly, but the slightest carelessness will cause them to smoke badly. At best, they need careful watching at all times.

Continuous Feed-Water Regulator

The use of the steam-flow meter has brought to notice the surprising variation in the rate of steaming of individual boilers. A boiler supposed to be running at a given capacity would be shown by the diagram from the meter to be running at times at twice its average capacity, while at other times its output would be practically stopped.

The method of introducing the feed water has much to do with the rate of steaming, as may be appreciated when the effect of pouring a dipperful of cool water into a boiling kettle is considered. If the water is dribbled in only fast enough to replace that evaporated, the steaming will go on at a uniform rate, while if the replenishing is done by the dipperful the boiling will be intermittent. Aside from its effect upon the steaming, abrupt changes in the rate of feeding are not conducive to good results with water meters, especially of the Venturi or pitot-tube type.

In view of these facts, particular interest attaches to a feed-water regulator which will maintain an approximately constant water level by regulating the rate of flow rather than by admitting the feed intermittently. Such a regulator, invented by Frederick L. Ray, and manufactured by the Ray Manufacturing Co., of 1035 Edwards Ave., Louisville, Ky., is shown in Fig. 1.

A piston valve, operated by the float in an obvious manner, controls the passage of the feed water from the inlet to the outlet port, adjusting the opening at *A* to that required to supply the water as fast as it is evaporated. By turning the handwheel *B* to the right, the valve may be pushed open positively in case of necessity, or its freedom tested.

At full load, when the valve is wide open, the water level will be about 2½ in. lower than when the valve is just opening, which is an advantage, giving a large body of heated water to draw upon at the time of greatest demand. When the load is light, the water level rises, and a considerable amount of extra water is heated up ready for increasing demand.

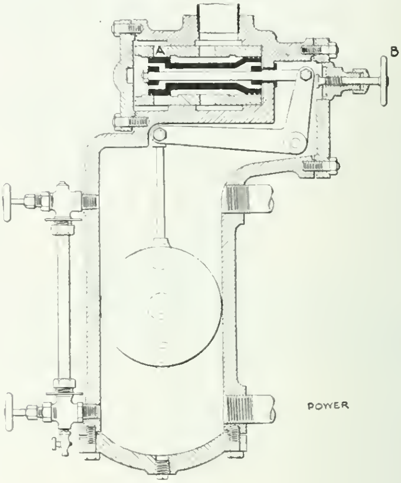


FIG. 1. RAY CONTINUOUS FEED-WATER REGULATOR

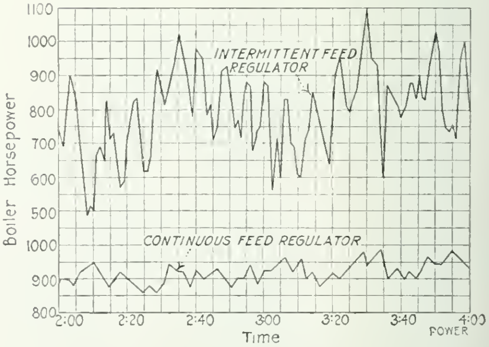


FIG. 2. CHARTS COMPARING INTERMITTENT AND CONTINUOUS FEED

The float chamber is fitted with gage cocks and water glass, thus serving as a water column, and may be fitted with high- and low-water alarms if desired. Fig. 2 shows diagrams from the same boiler when controlled by regulators of the continuous- and intermittent-flow type.

* * *

To Repair Small Leaks in Lead Pipes, place the point of a dull tool or nail over the leak, give it a gentle tap with a hammer and the flow will cease.

Editorials

Engineers' License and Boiler-Inspection Laws

With September the annual struggle for legislation which shall reduce the loss of life and property from boiler and other power-plant accidents will begin under perhaps the most auspicious circumstances and with more numerous and potent influences operating in its favor than ever before.

On the first three days of the month the annual convention of the American Boiler Manufacturers' Association is to be held in New York. Wednesday will be devoted to a discussion of boiler legislation and uniform specifications. The Association is committed to the furtherance of uniform inspection laws, the members are interested in having such laws right, and there is little doubt that the discussion of such laws will be an important feature of the meeting.

During the second week the annual convention of the National Association of Stationary Engineers will be held in Milwaukee. This association, through a national committee and various local organizations, is working for the passage of laws providing for the examination and licensing of engineers. The report of the national committee, the discussion of results accomplished and the planning and providing for the work of the coming year should be helpful and inspiring. An organization of upward of twenty thousand men, even if they are scattered over forty odd states, ought to have some weight with the lawmakers if their influence is properly directed.

And then on the fifteenth there is to be held in the Engineering Societies Building in New York, under the auspices of a committee of the American Society of Mechanical Engineers, a hearing upon the form of law and code of boiler rules, which that committee recommends for universal adoption. The law properly provides for inspecting the personnel as well as the apparatus, for the best boiler ever made can be exploded by a careless or ignorant attendant, and the better the boiler the more disastrous is the explosion liable to be. The acknowledgement by a great national professional society like the Mechanical Engineers that the necessity for such legislation exists ought to insure intelligent attention to the measures, based upon the committee's report, which will be submitted to the various legislatures during the coming winter; and once the necessity or desirability of such legislation is admitted, the argument for the adoption of a uniform law which embodies the concrete wisdom of the best engineers and specialists of the country appears to be invincible.

For over thirty years POWER has been urging the passage of such laws not only in its columns but by argument before legislative committees, appeals to influential employers and other activities. Progress has been slow. The "Let us alone" policy has prevailed because those who wanted to be let alone had a bigger hand in the making and operating of legislatures than did the public whose safety was involved. But with a growing recognition of the importance of industrial losses, with all the significance attached to the slogan Safety First and with such sponsors as those above mentioned, American legislation for this purpose must come eventually if late.

*

Supervision of School Heating and Ventilating

The board of education of New York City is considering the advisability of placing engineering matters connected with public-school buildings under the direction of an engineering bureau, as mentioned on page 326. Inasmuch as the legislatures of most of the states have made it mandatory on school authorities to provide adequate facilities for heating and ventilating this class of public buildings, it may surprise the average layman to learn that the equipping and operating of these important engineering features of school buildings of the metropolis, instead of being supervised and controlled by trained and experienced heating and ventilating engineers, are under the authority and direction of architects acting as deputy superintendents of school buildings of the five boroughs.

This way of conducting so important a branch of school work seems to be a relic of the days when the highest aims of schoolhouse construction were satisfied by artistic design and ample seating capacity and when the profession of heating and ventilating was unknown. Few architects, however, who are entrusted with the construction of buildings wherein these features are of serious importance, feel qualified to work out their problems without the guidance of specialists. Even then, too often, the operative appointments are made to so far subserve architectural impressions that small opportunity is afforded the heating and ventilating engineer to design a system that can be operated with certainty and efficiency.

No matter how creditable the design, a heating and ventilating apparatus cannot take care of itself. Time and again, good designs have been condemned for want of expert supervision: numerous ventilating systems of hospitals, schools, and other public buildings have been pronounced failures where ample provisions had been made for ideal atmospheric conditions. In nearly every instance failure was due to subsequent architectural limitations or an absence of skillful technical guidance in their operation.

The problem confronting engineers has been to provide systems that could not be abused rather than those capable of the most successful operation. If managers of schools wish a fair return for their investment in heating and ventilating apparatus, the least they can provide is expert supervision, and they should take that intelligent view of the situation which it is believed the board of education of New York City will take in placing the heating and ventilating of school buildings in all branches of design and operation under the supervision and control of a heating and ventilating bureau.

Book Knowledge Theoretical?

Is all knowledge gained from books merely theoretical knowledge? Many of the questioning remarks heard in the nooks and crannies of the industrial world about the value of theoretical knowledge in the power plant, lead one to suspect the existence of a more or less widespread misunderstanding on this point. A power-plant engineer speaks with apparent pride of having got by experience all his knowledge of power plants and their operation and speaks slightingly of the knowledge another man professes to have gained by the reading and study of books. His own he calls "practical" knowledge, the other man's he calls "theoretical" knowledge, if indeed he admits that it is knowledge. Let us take a look into this question from another viewpoint.

The North American Indian bothered his head very little about what we sometimes call "theories." When he and his squaw and papoose needed shelter, he set up a few poles of various lengths in such a manner as to form a cone-shaped frame (although perhaps he did not try to coin a word to describe the shape), and then without yardstick or rule, or without making any attempt to calculate the number of pelts required, the red man used his bow and arrows on the beasts of the forest until he had bagged enough of their skins to cover the frame of his wigwam. With no thought or care about measurements or proportions this primitive man builds a house which has dimensions—height, diameter, circumference—builds it on such lines as to make sure it will shed rain and emit the smoke from his fire through an opening in the top. It was, after all, then, built according to a "theory," even though that theory had never been recorded in rude characters on birch bark, but had been handed down in the traditions of his tribe. Only among men of more highly developed mental faculties, who construct larger and more elaborately finished dwellings than did the Indian, do we find the work of construction carried on in accordance with certain laws regarding proportion, protection from weather, heating and ventilation, convenience, acoustics, etc. (And perhaps somewhere in the woods we might find "practical" builders who would call these laws and principles "theories.")

And during the centuries that intelligent men have been building houses, so many good ideas and valuable facts about building for better service have been discovered that no one man can remember them all, or hand them down safely by the mouth-to-ear plan. Hence, builders have set down in writing what they discovered or learned by experience, and this information has been gathered and published in book form. As each new generation of builders grows up and begins work, the wiser men among them read these books, get from them, in three or four years, practically all their forefathers knew about the subject, and then start in about where the men of the former generation left off in the art of building. Of course, some of the beginners push aside this "book knowledge," because they consider it "theoretical" and "impractical." These men refuse to profit by the experience of their forefathers and in consequence build less desirable houses than did their fathers. If you want proof, just look around any community and see how many badly designed and poorly constructed houses there are, and how few well designed and well built. What many men call "theories" about building are simply statements of the laws or rules that builders have found it well to observe in the construction of houses. The "theories" are based upon "practice."

The same principle and rule apply to engineering. All that is written above about learning to build houses better by reading books on building houses is equally true of power-plant engineering. The engineer is not wasting time—he is saving time—by reading books on his branch of work, provided he selects the right books. Some men have failed to recognize the difference in books. It is true that some books are mere efforts to expound hypotheses. But other books are accurate records of actual experiences and demonstrated facts. These last-mentioned books are not theoretical, in the strict sense of that word. They are intensely practical. The trouble is that we have got into the habit of classing as "theoretical" whatever is written. This is a mistake. The thing that drove some men to writing books was the discovery of many facts—multitudes of facts—so many facts that no man could remember them all and hand them on to other men by word of mouth. Books written for the purpose of recording and conveying such information are not merely theoretical and should not be discounted. They are authentic records of past practical experience and discovery by experiment. They should be read and duly credited. They form the bridge over the chasm of doubt on their subjects. They provide the true "short cut" from ignorance to practical and workable knowledge. They place the reader years in advance of his fellows who tie themselves to their own experience or observation for getting knowledge. They provide a groundwork for real experience that is truly useful and valuable. They give us the chance to avail ourselves of the accumulated knowledge of the past generations. They enable us to profit by and to enjoy the fruits of our forefathers' labor.

Let us get straight this question of what is really "theory" and what in contrast is the record of practice, and then, instead of robbing ourselves by a mistaken conception, we shall profit immensely by using the knowledge gained by our ancestors at such enormous cost.

* * *

If anyone has overlooked the cartoon and happens to wonder at the amount of matter relating to Milwaukee in this issue, we would hasten to explain that the National Association of Stationary Engineers will hold its annual convention in that city, September 7 to 12. For the benefit of those who will attend the meeting, a number of places of special interest to engineers have been referred to including Milwaukee's largest power plant, the Commerce Street station of the Milwaukee Electric Railway & Light Co., page 290; the Schlitz Brewery Plants, page 322; and the several other plants covered under the general title "Plants of Interest in Milwaukee," page 301. Those who are not going to the meeting may especially want to read the Milwaukee articles as they will not have the opportunity of seeing the places described.

* * *

If you do not record the coal consumption and entire output, you can never know how much steam can pass through a small hole.

Correspondence

Changing from 440 to 220 Volts

Answering the question of M. F. on p. 145, July 28 issue, the accompanying diagrams show changes made on two G. E. 440-volt three-phase induction motors to adapt them for service on 220 volts.

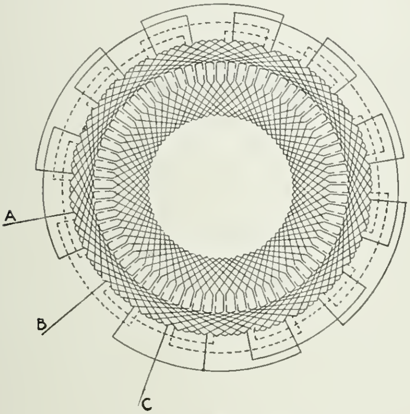


FIG. 1. SERIES-STAR WINDING FOR 440 VOLTS

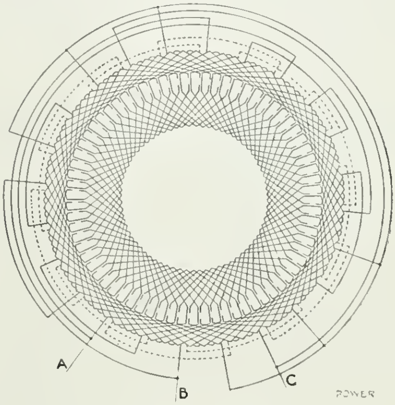


FIG. 2. TWO-CIRCUIT STAR WINDING FOR 220 VOLTS

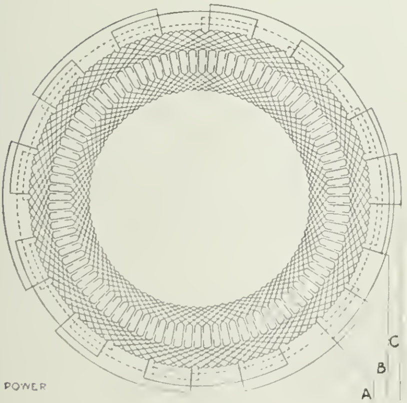


FIG. 3. SERIES-DELTA WINDING FOR 440 VOLTS

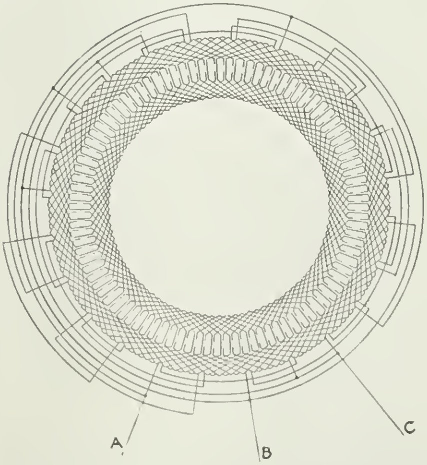


FIG. 4. TWO-CIRCUIT DELTA WINDING FOR 220 VOLTS

The motor shown in Fig. 1 had a series-star-connected stator. The end connections between the groups of coils were unsoldered and reconnected two-circuit star as shown in Fig. 2. This will be readily seen by tracing out the windings for each phase, starting at *A*, *B* and *C*.

Fig. 3 shows a series-delta-connected stator. The end connections were rearranged as shown in Fig. 4, and both motors operated very satisfactorily with the changed connections.

In a 440-volt motor the groups of coils between phases are as a rule connected in series. If such is the case, it is only necessary to reconnect the groups in two parallel series circuits between phases to make them suitable for operation on half the original voltage.

P. Justus.

Cleveland, Ohio.

To change a three-phase, 440-volt induction motor for 220-volt service, first find out the number of coils per phase per pole in the stator winding. If the number per pole is exactly divisible by 2, then each pole winding is easily separated exactly in the middle. These two windings are then connected in parallel with the interconnecting leads tapped to the same coils as before. Care must be taken to see that the parallel leads are similarly connected on every pole and that all interconnections remain as before. The revolutions per minute will practically remain as before, with similar load conditions.

Ben Dawson.

Cedar Rapids, Ia.

⁂

Correcting Defect in Breeching Design

Occasionally, a good piece of power-plant apparatus fails of satisfaction because of the faulty design of the other apparatus with which it is connected. A case was brought to the writer's attention when asked to investigate the cause of an excessive amount of carbon in the refuse at a stoker-fired plant. This boiler plant is at a cement mill in the Middle West and uses coal mined in southeastern Kansas. The steam-generating plant consists of six 300-hp. water-tube boilers set in three batteries. Four of the units are equipped with chain grates, each having 72 sq.ft. of grate area and the other two, not being required, are disconnected from the breaching and all the steam lines.

For several years, the plant was oil fired, but this proved expensive on account of the price of oil prevailing at that time and because of the frequent renewal of the brickwork. The boilers were equipped with standard Bonus type baffles and the gases passed through an underground tunnel below the rear of the boilers to a stack outside the boiler room. At the time stokers were installed, the boiler baffles were changed to the horizontal type, as shown in Fig. 1, and a new breaching was constructed above the boilers and connected to a 175-ft. steel stack.

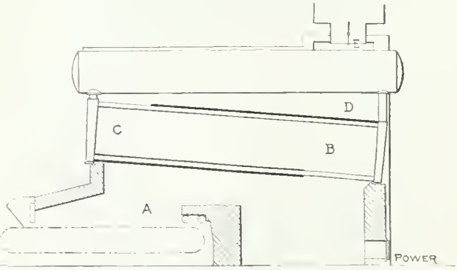
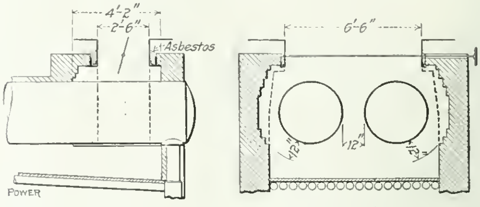


Fig. 1. Showing Points at Which Draft Was Measured

The stoker manufacturer had guaranteed to develop 130 per cent. boiler rating based on 10 sq.ft. of heating surface per horsepower and to secure a combined efficiency of boiler, furnace and grate of 68 per cent. For the performance of this guarantee, it was stipulated that the coal should contain at least 10,500 B.t.u. per pound as fired and that the furnace draft should be equivalent to 0.3 in. of water. It was reasonable to expect this intensity of draft with normal conditions, but a series of draft readings (Table 1) showed an abnormal loss at the rear drum pass and as a result the furnace draft was low. Internal inspection of the cold setting at once located the trouble. It appeared that in changing the brickwork, the proportioning of gas passages had been left to the judgment of the bricklayers. The openings where the gases pass upward about the drums to the uptake had been built as shown by the dotted lines in Fig. 2, thus giving a total area of only 5.5 sq.ft. Consequently it was necessary to tear down part of the brickwork and increase these areas by corbelling back as shown by the full lines, thus securing an area of 12.7 sq.ft.



Longitudinal Section

Transverse Section

Fig. 2. Dotted Lines Represent Contracted Uptake and Solid Lines That after Corbelling

TABLE 1

Point of Observation	Intensity of Draft, Before Correcting Defect	Inches of Water After Correcting Defect
A	0.18	0.35
B	0.25	0.38
C	0.38	0.45
D	0.49	0.64
E	1.05	0.85

The original net areas at various points (Fig. 1) in the path of the gases and the corresponding areas after making the change are given in Table 2. Table 1 shows the draft readings taken before and after making the changes, all readings having been taken with a $5\frac{1}{4}$-in. fire, with the grates completely covered and with the boiler damper wide open. The CO_2 just below the damper averaged 10 per cent. After slightly reducing the opening between the waterback and the grate and operating with the increased draft, the coal was burned out to satisfactory ash and the boilers easily generated the over-rating specified.

TABLE II

Passage	Area in Square Feet Before Correcting Defect	After Correcting Defect
Grate surface	71.3	71.3
Over bridgewall	22.0	22.0
Lower baffle opening	15.0	15.0
Around tubes between upper and lower baffle	16.4	16.4
Upper baffle opening	8.75	10.6
Between drum and top of upper baffle	12.0	12.0
At sides and between drums at the rear	5.5	12.7
Damper	16.2	16.2

Such mistakes sometimes occur because of the inexperience of the designer, and it is a good plan always to ask the advice of the builders of a piece of apparatus before attempting to make radical changes. In the above case, considerable expense could have been saved, though fortunately there was no interference with the operation of the plant, as the mistake was discovered before the machinery was ready for continuous running.

It is well to remember that gas passages should be so proportioned that the velocity does not exceed 40 ft. per second when the maximum capacity is developed and, in cases like the above, where the passage is divided into three parts, the velocity should be lower. It is estimated that the velocity in the present case will average about 30 ft. per second when operating at maximum rating.

W. M. Park.

Fort Worth, Texas.

⁂

Voltage Combinations

Answering C. D.'s inquiry in Power for July 28, page 145, the following sketches show the method of obtaining simultaneously 110-220-volt, three-phase, three-wire, and 110-220-volt, single-phase, three-wire service from one set of standard 2300-volt primary, 110-220-volt secondary, single-phase transformers connected to a 2300-volt, three-phase, three-wire primary line. The theme is an interesting one to a student of polyphase currents and has been developed with the view of showing what could be accomplished if necessary rather than what should be done.

In accordance with the request, two cases are considered, an open and a closed one. Two sketches are shown for each case, one showing the transformer connections and the other the phase relations by the conventional method, the inner lines representing the primary and the outer lines the secondary windings; moreover, the lettering is consistent throughout, capital letters designating the primary lines and small letters the secondary circuits.

Case I—Two transformers with primaries and secondaries in open delta, giving a five-wire secondary with five circuits, as follows:

One 220-volt, three-phase, three-wire, lines *a-b-c*.

One 110-volt, three-phase, three-wire, lines *d-b-e*.

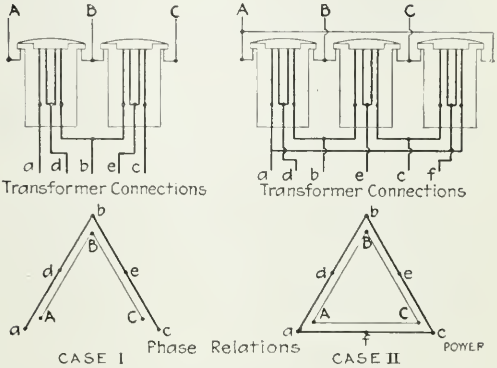
Two 110-220-volt, single-phase, three-wire, lines *a-d-b* and *b-e-c*.

One 220-volt, single-phase, two-wire, lines *a-c*.

This latter circuit may also be used for such 110-volt, single-phase devices as may be operated two-in-series on 220 volts.

The open-delta connection, while comparatively simple, has several disadvantages. A balanced load will not be obtainable, the best condition being with the 110-220-volt, single-phase load (with the exception of such as may be used on circuit *a-c*) divided as nearly as possible into two equal circuits, well balanced as to the 110-volt devices, and these two circuits supplied by transformers *a-d-b* and *b-e-c*. Even under these conditions, that portion of the secondary windings included between *d-b* and *b-e* will carry the greatest load.

The transformers should be selected with a rating in kv.-a. not less than 220 times the sum of the ampere ratings of all the three-phase devices, plus the sum of the ampere ratings of the 220-volt, single-phase devices plus one-half the sum of the ampere ratings of the 110-volt, single-phase devices. Ample transformer capacity should be provided as an insurance against interruptions due to burnouts, the loss of either transformer entailing the interruption of four out of the five circuits, all except the 110-220-volt, single-phase circuit from the remaining transformer.



Transformer Connections for Desired Voltage Combinations

Line wire *b* should be of ample cross-section, as this is a part of all circuits except the 220-volt, single-phase circuit *a-c*.

Case II—Three transformers with the primaries and secondaries in closed delta, giving a six-wire main with eight circuits, as follows:

One 220-volt, three-phase, three-wire, lines *a-b-c*.

Four 110-volt, three-phase, three-wire, lines *a-d-f*, *b-e-d*, *c-f-e*, *d-e-f*.

Three 110-220 volt, single-phase, three-wire, lines *a-d-b*, *be-c*, *c-f-a*.

While this method is not so simple as that of Case I, it permits the load to be more nearly balanced, the degree depending upon the relations of the various classes of load and the engineering skill used in apportioning the load between the several circuits. The burnout of one transformer in this case would result in the loss of three out of the four 110-volt, three-phase circuits completely and limit the usefulness of one of the 110-220-volt, single-phase circuits, producing the condition of Case I.

In practice, the various secondary wires should be consistently marked at all junctions and taps as an aid in time of trouble, and if the scheme of Case II is adopted, these markings would permit temporary connections to be made and thus reduce the time the apparatus would be out of commission due to line or transformer troubles.

The voltage regulation of an installation of this character would be influenced so much by local conditions of which no information is given that comment is withheld, except to say that with a delta-connected circuit independent regulation is possible on but two phases, the voltage on the remaining phase being the resultant of the other two. With sufficient copper in the primary and secondary mains, and ample transformer capacity, satisfactory conditions could probably be obtained.

R. Arthur Joslyn.

Roxbury, Mass.

Engineers' Study Course

Elementary Mechanics--XXIV

LAST LESSON'S ANSWERS

106. From equation (59) $P = \frac{W \times H}{L}$. In this problem W = 1600 lb.; H = 1 ft.; and L = 12 ft. so that

$$P = \frac{1600 \times 1}{12} = 133\tfrac{1}{3}\ lb.$$

107. The horizontal force P necessary to hold the body at rest on the plane is $W \frac{sin\ a}{cos\ a} = W\ tan\ a$. Since the plane rises 1 in 12 $sin\ a = \frac{1}{12}$ or a = 4 deg. 47 min. Therefore the force

$$P = 1600 \times tan\ 4\ deg.\ 47\ min. = 1600 \times 0.0836 = 133.8\ lb.$$

108. The force of friction F = the coefficient of friction f times the normal pressure, or

$$F = f\ W\ cos\ a = 0.18 \times 1600 \times 0.9965 = 0.18 \times 1594 = 287\ lb.$$

The force of gravity tending to move the body down the plane is

$$W\ sin\ a = 1600 \times 0.0833 = 133\ lb.$$

The force P necessary to prevent motion down the plane must equal the force of gravity minus the force of friction or,

$$P = G - F = W\ sin\ a - f\ W\ cos\ a = 133 - 287 = -154\ lb.$$

The fact that the value of P works out negative shows that under the given conditions the force of gravity is not sufficient to overcome the force of friction, so that to move the body down the plane an additional force P must be applied. (See answer to problem 110.)

109. For the body to be on the point of moving up the plane the force P must overcome both the force of gravity and the force of friction. From the previous problem the force of friction is 287 lb. and the force of gravity 133 lb. Therefore the force

$$P = F + G = 287 + 133 = 420\ lb.$$

Any value of P between —154 lb. and +420 lb. will hold the skid at rest on the plane.

110. The force P will act down the plane when the force of friction up the plane is greater than the force of gravity down the plane. This will occur when the tangent of the angle a is less than the coefficient of friction for it was shown in lesson XIV that when a body is just on the point of moving down a plane the coefficient of friction f is equal to the tangent of the angle made by the plane with the horizontal. (See solution of problem 108.)

INCLINED PLANE (CONTINUED)

As a final example under case II let the force P, Fig. 73, act parallel to the base of the plane, and assume that the body is on the point of moving up the plane, under which condition both the force of gravity and the force of friction will act down the plane, thus opposing the upward force which is the component of P parallel to the plane.

Resolve the horizontal force P into two components parallel to and at right angles to the plane by constructing the parallelogram $RMSGR$. The component RG, parallel to the plane will tend to move the body up the plane. The component SG will tend to increase the normal pressure between the weight and the plane, thus increasing the force of friction. Also resolve the weight W into two components parallel to and at right angles to the plane.

The force of gravity G, acting down the plane is equal to the component EF or $W\ sin\ a$. The total normal pressure between the weight and the plane is the sum of the components SG and GF where

$$SG = MR = P\ sin\ a$$

and

$$GF = W\ cos\ a.$$

From equation (22) the force of friction F, acting down the plane is equal to the total normal pressure N, times the coefficient of friction f, or,

$$F = f \times N$$

where

$$N = SG + GF = P\ sin\ a + W\ cos\ a;$$

hence

$$F = f\ (P\ sin\ a + W\ cos\ a).$$

The effective force tending to move the body up the plane is the component of the force P parallel to the plane or RG which is equal to $P\ cos\ a$. For equilibrium to exist, the forces F and G acting down the plane must equal the force RG, or $P\ cos\ a$, acting up the plane, whence,

$$P\ cos\ a = F + G$$

or

$$P\ cos\ a = f\ (P\ sin\ a + W\ cos\ a) + W\ sin\ a.$$

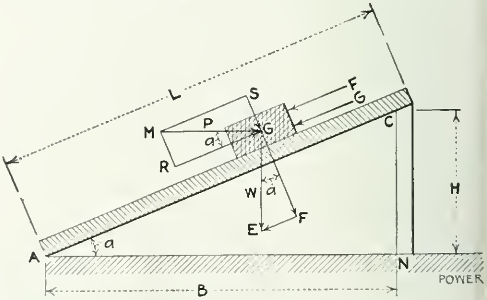


FIG. 73.

To find the relation between P and W, solve the above equation by collecting all the terms involving P, thus,

$$P\ cos\ a - f\ P\ sin\ a = f\ W\ cos\ a + W\ sin\ a$$

now divide both sides of the equation by $cos\ a$, then

$$\frac{P\ cos\ a}{cos\ a} - \frac{f\ P\ sin\ a}{cos\ a} = \frac{f\ W\ cos\ a}{cos\ a} + \frac{W\ sin\ a}{cos\ a},\ or,$$

$$P - f\ P \frac{sin\ a}{cos\ a} = f\ W + W \frac{sin\ a}{cos\ a}\ \text{and}$$

$P\ (1 - f\ tan\ a) = W\ (f + tan\ a)$, since $\frac{sin\ a}{cos\ a} = tan\ a$, therefore

$$P = W\left(\frac{f + tan\ a}{1 - f\ tan\ a}\right) \qquad (64)$$

When the weight W is on the point of moving down the plane then the force of friction will act up the plane or,

$$G = P\ cos\ a + F$$

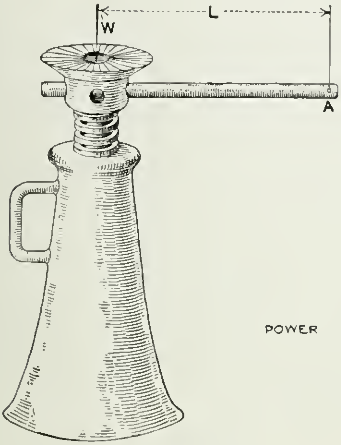


FIG. 74.

$$W\ sin\ a = P\ cos\ a + f\ (P\ sin\ a + W\ cos\ a)$$

and

$$P\ cos\ a + f\ P\ sin\ a = W\ sin\ a - f\ W\ cos\ a$$

hence, dividing through by $cos\ a$,

$$P + f\ P\ tan\ a = W\ tan\ a - f\ W$$

or

$$P = W\frac{tan\ a - f}{1 + f\ tan\ a} \qquad (65)$$

Any value of P between those given by equations (64) and (65) will hold the body at rest on the plane.

The efficiency of the inclined plane as a machine for the performance of useful work may be readily determined. In Fig. 73, when the weight has moved from A to C, the useful work performed is just the same as if the weight W had been raised in a vertical direction from the point N to the point C. Hence the net result of sliding the weight up the plane is the overcoming of a resistance of W lb. through a vertical distance of H ft. or the output of the machine is $W \times H$.

The work done on the body by the force P in moving the body up the plane is $P\ cos\ a$ (resistance) times L (distance); but $L\ cos\ a = B$ (the base of the plane), therefore the input $= P \times B$.

From equation (53) $efficiency = \frac{output}{input}$.

Let $E =$ the efficiency of the inclined plane whose slope is a deg., then, $E = \frac{output}{input} = \frac{W \times H}{P \times B}$ but $\frac{H}{B} = tan\ a$ and $P = W\left(\frac{f + tan\ a}{1 - f\ tan\ a}\right)$ hence

$$E = \frac{W\ tan\ a}{W\left(\frac{f + tan\ a}{1 - f\ tan\ a}\right)} = \frac{tan\ a\ (1 - f\ tan\ a)}{f + tan\ a}$$

The above equation may be simplified by dividing numerator and denominator by $tan\ a$, thus, $E = \frac{1 - f\ tan\ a}{\left(\frac{f}{tan\ a}\right) + 1}$, or,

$$E = \frac{1 - f\ tan\ a}{1 + f\ cot\ a} \qquad (66)$$

(Note: $\frac{1}{tan\ a} = cot\ a$. See lesson III in Trigonometry).

Equation (66) is useful in determining the efficiency of a screw jack, a screw press or the efficiency of screw threads.

Turning a nut on a rod on which a thread has been cut is just the same as moving a body up an inclined plane by the aid of a horizontal force. The height of the plane NC, Fig. 73, corresponds to the pitch of the thread, the length L is the development of the thread, and the base B is the circumference of the bar on which the thread is cut. The inclination of the plane is the angle of the thread.

Example—The angle of a given screw thread is 6 deg. The coefficient of friction between the nut and the thread is 0.15. Find the efficiency of the screw. In this case

$$tan\ a = tan\ 6\ deg. = 0.105$$

and

$$cot\ 6\ deg. = 9.514$$

Substituting these values in equation (66), there results:

$$E = \frac{1 - f\ tan\ a}{1 + f\ cot\ a} = \frac{1 - (0.15 \times 0.105)}{1 + (0.15 \times 9.514)} = \frac{0.984}{2.427}$$
$$= 40.5\ per\ cent.$$

STUDY QUESTIONS

111. In the screw jack shown in Fig. 74, there are four threads per inch and the diameter of the screw is 2 in. Assuming the coefficient of friction as 0.14, find the efficiency of the jack.

112. A man exerts a pressure of 40 lb. at the point A, located 24 in. from the center of the jack. Find the maximum weight W that he can raise, neglecting the inertia of the weight.

113. A loaded coal car weighing 2000 lb. starts down an incline whose slope is 1 in 18. If the frictional resistance is 20 lb. per ton, find the acceleration with which the car will move down the plane.

114. If the plane is 500 ft. long, find the velocity of the car when it reaches the foot of the incline.

115. How far will the car run on the level before coming to rest. [Figure the kinetic energy of the car when it reaches the foot of the incline and then find the distance from equation (57).]

CORRECTION—In the statement of question 96, Lesson XXI, Aug. 11, 1914, "a pressure of 120 lb. per sq.in." should have read "a head of 120 ft." The answer given in the next lesson would then be correct. As it was stated, the answer should be 2.3 times that given, or

$$2.3 \times 30.3 = 69.69\ \text{hp.}$$

since 1 lb. pressure = 2.3 ft. head.

The answer to question 98, Lesson XXII, Aug. 18, 1914, was in error in that it did not take account of the 75 per cent. efficiency assumed between the engine and the load. The answer should be

$$\frac{3\frac{1}{3}}{0.75} = 4\frac{4}{9}\ hp.$$

At best the problem does not admit of an exact practical answer, as explained in the paragraph following the answer given.

Inquiries of General Interest

Temperature of Superheated Steam—What would be the temperature of steam at 150 lb. gage pressure superheated 250 deg.?

R. J.

The temperature of dry-saturated steam at 150 lb. gage pressure being 366 deg. F., when superheated 250 deg., the temperature would be 366 + 250 = 616 deg. F.

Safety of Flywheel—If the centrifugal force which tends to burst a flywheel rim is directly proportional to its weight, why is it that increasing the size of the rim would not increase the danger of rupture?

D. J.

Because the cross-sectional area, and consequently the strength of the rim, would be increased in direct proportion with the increase of weight.

Della Porta—Who was della Porta and what connection had he with the development of the steam engine?

S. D.

Giambattista della Porta (1543-1615) was an Italian physicist who published, A. D. 1601, a treatise in which he shows an apparatus similar to Hero's fountain, but with steam in place of air as the displacing fluid. His suggestions fully anticipate the engine which a century later was developed by Savery as the earliest commercially successful steam engine.

Filtering Air for Indirect Heating—How can dust be prevented from being carried into buildings which are heated by indirect blower systems?

R. M.

The fresh air should be taken into a settling chamber and thence drawn through a number of screens of heavy cheesecloth. The screens should be spaced several feet apart and have from five to ten times the area of the supply ducts, so that the air may pass through the screens at low velocity. The settling chamber and screens should frequently be cleaned.

Length of Belt Splices—What is the proper length for splicing joints of single and double leather belts, 4 to 18 in. wide?

G. H. L.

Most manufacturers make the scarf length equal the belt width for all single and double belts, down to 5 in. wide; and for belts of less than that width make the scarf about 1 in. longer than the belt width. Double belts over 10 in. wide should have the scarf ends each covered with a tuck or dovetail, formed by a narrow overlap of the corresponding thickness of the opposite end of the belt.

Oil in Condensate—How can the presence of oil in return water from exhaust steam heating be determined?

P. M. R.

A fair test of the amount of engine cylinder oil contained in a sample of condensation may be made by determining how much oil has to be added to a given quantity of fresh water to cause the latter to present the same appearance of turbidity when equal quantities of each kind of water are mixed with the same quantity of any given solution of sodium hydrate (caustic soda). Care should be taken that all solutions are employed at the same temperature.

Effect of Clearance on Mean Effective Pressure—For a given point of cutoff, what effect has the cylinder clearance on the resulting mean effective pressure?

P. M. G.

Clearance has the effect of increasing the mean effective pressure by increasing the mean forward pressure and decreasing the mean back pressure. This is because steam which expands after cutoff includes that which fills the clearance space; hence the greater the percentage of clearance the greater the average forward pressure; and on the return stroke, as the amount of compression is inversely as the volume, the average back pressure will be less the greater the percentage of clearance.

Advantages of Centrifugal Pumps—What are the advantages of centrifugal over reciprocating pumps, and more especially as boiler feeders?

W. B.

The leading advantages of centrifugal pumps are compactness, silent running, durability and superior economy in cost of power, attendance and repairs, and the facility with which they may be adapted to any location where they may be supplied with power by direct connection to an electric motor or steam turbine. As boiler feeders, they have the advantage over reciprocating pumps of continuous delivery without shock or hammering, and of producing no excessive pressure on feed mains for any adjustment of feed stop valves or other stoppage of pipe connections.

Water Horsepower—What would be the water horsepower in pumping at the rate of 200 gal. of water per minute against a pressure of 80 lb. per sq.in.?

R. B.

Taking the weight of 1 gal. of water as 8⅓ lb., the weight of water pumped per minute would be

$$200 \times 8\tfrac{1}{3} = 1666.66 \text{ lb.}$$

A pressure of 1 lb. per sq.in. is equivalent to the pressure created by a column of water 2.309 ft. high and pumping against 80 lb. pressure would be equivalent to pumping against a head of 2.309 × 80 = 184.72 ft., or raising the water to that height. The energy developed would be

$$1666.66 \times 184.72 = 307{,}865.43 \text{ ft.-lb. per min.}$$

or

$$\frac{307{,}865.43}{33{,}000} = 9.33 \text{ hp.}$$

Dimensions of Cylinder—If the volume of a cylinder is 11.78 cu.ft. and its length is 2½ times its diameter, what would be the diameter and the length?

J. J. F.

If

d = The diameter in feet, and

l = The length of the cylinder,

then as the cross-sectional area would be

$$d^2 \times 0.7854,$$

the volume would be

$$d^2 \times 0.7854 \times l.$$

As $l = 2\frac{1}{2}\,d$, and the given volume is 11.78 cu.ft. then

$$d^2 \times 0.7854 \times 2\tfrac{1}{2}\,d = 11.78 \text{ cu.ft.,}$$

from which we find

$$d^3 = 5.999 \text{ and}$$

$$d = \sqrt[3]{5.999} = 1.817 \text{ ft.,}$$

and the length would be

$$2\tfrac{1}{2} \times 1.817 = 4.542 \text{ ft.}$$

Formula for Shafting—What is the rule for estimating the safe number of horsepower transmitted by iron or steel shafting when properly lined up and supported?

B. F. A.

The safe transmitting capacity of a 1$\frac{15}{16}$- or nominal 2-in. diameter shaft, with the usual bending strains of pulleys, belts, etc., is 10 hp. at 100 r.p.m. The torsional resistances of shafts are as the cubes of their diameters, and the number of horsepower transmitted by any given size is directly in proportion to its speed of rotation. Hence for finding the power capable of being transmitted by any size shaft at any number of revolutions per minute: Multiply the cube of its diameter in inches by the revolutions per minute and by 10 and divide by the cube of 2, multiplied by 100; or expressed in a formula wherein

d = diameter of shaft;

n = number of revolutions per minute;

$$\frac{d^3 \times n \times 10}{2 \times 2 \times 2 \times 100} \text{ or } \frac{d^3 n}{80} = \text{hp.}$$

For example, the safe number or horsepower which a 3-in shaft, running at 200 r.p.m., could transmit would be

$$\frac{(3 \times 3 \times 3) \times 200}{80} = 67.5 \text{ hp.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Nordberg Oil Engine

An oil engine for general power-plant purposes, irrigation, etc., has just been perfected by the Nordberg Mfg. Co., of Milwaukee. It is of the single-acting two-stroke-cycle type and of heavy construction, as may be seen from Fig. 1. The crank end is of steam-engine design, that is, the engine is provided with a crosshead having adjustable babbitted shoes and a standard Nordberg wristpin. The crankpin bearing is of the marine type and all moving parts are counterbalanced.

Simplicity has been the keynote of the design, there being no valves except one for admitting scavenging air, so that the usual valve gear is lacking. Ignition is effected by the heat of compression, and the fuel supply is controlled by the governor. The clearance space is almost semispherical and the cylinder and cylinder head are thoroughly water-jacketed.

As shown in Fig. 2, the crank end of the cylinder is inclosed and a stuffing box is provided for the piston rod. Air for scavenging is drawn into this space on the back stroke of the piston, through a piston valve mechanically operated by an eccentric on the main shaft. Mechanical control permits a later closing of the valve, so that more air will be drawn in by the piston. On the forward stroke this air is compressed and through the bypass over the top of the cylinder is admitted to the combustion chamber when the piston uncovers the transfer port *A*. The volume of the bypass may be varied slightly to obtain the desired pressure. When the port is uncovered the air sweeps into the cylinder and is deflected so that it forces the burned gases through the exhaust port *B* at the bottom of the cylinder. On the return stroke the fresh air remaining is compressed to about 450 pounds

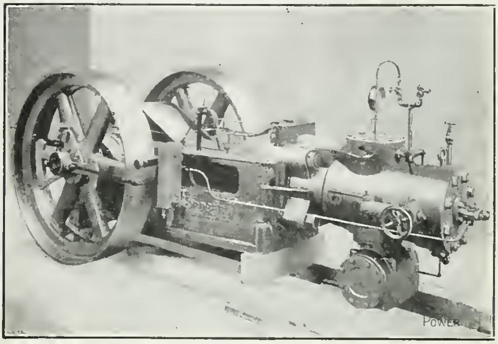


Fig. 1. General View of Nordberg Oil Engine

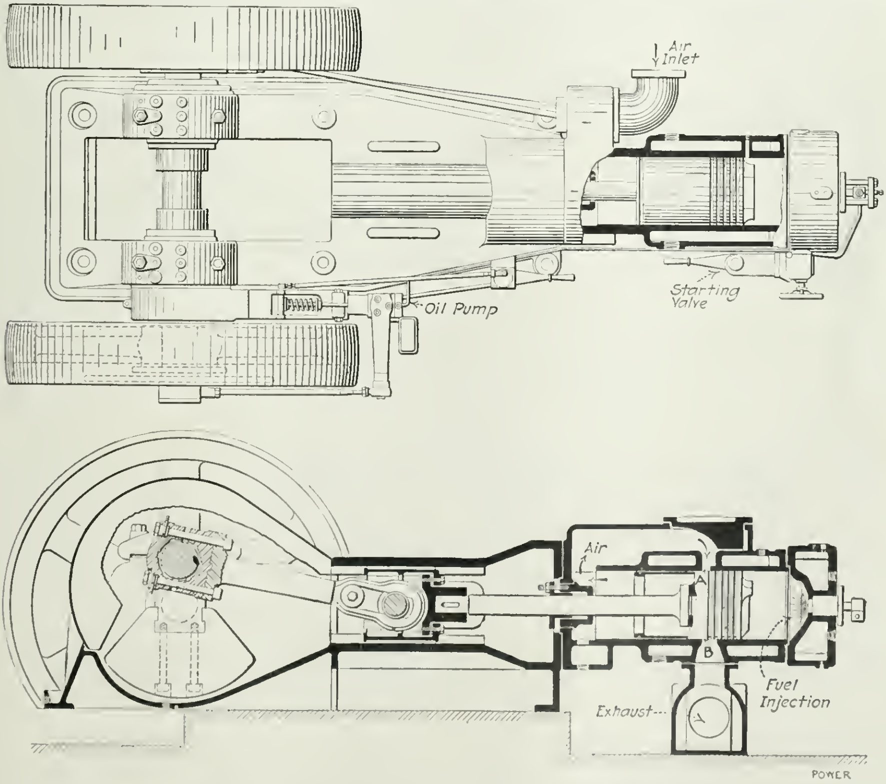


Fig. 2. Plan and Section of Nordberg Oil Engine

Near the end of this stroke a quantity of oil, determined by the governor, is injected by a pump through a fine nozzle and distributing device into the cylinder. The pump, which is of the plunger type, has a constant stroke. Consequently on every suction stroke it draws in the same quantity of oil. During discharge, however, part of the oil is returned to the suction through a bypass valve, its opening point being determined by the governor. On the pressure stroke the pump is positively driven by an eccentric on the main shaft and a cam which comes in contact with the plunger. The return stroke of the pump is effected by means of a spring; see Fig. 1.

An inertia flywheel governor of the pendulum type advances or retards an eccentric controlling the bypass valve of the oil pump. As little work is required of it, the governor is of light construction. A speed regulation to within two per cent. from no load to full load is claimed.

The engine is started in the usual way by compressed air, admitted through a spring-operated valve at the side of the cylinder. To insure against leakage when the engine is running, a hand-operated valve, shown in Fig. 1, is also provided. Lubrication is effected by a two-compartment positive feed pump having outlets to each bearing and one to the cylinder.

At present the engine is made in sizes from 50 to 100 hp., with speeds ranging from 270 to 300 r.p.m. Greater powers might, of course, be obtained by a duplication of cylinders.

* *

The Schlitz Brewery Plants

By Thomas Wilson

SYNOPSIS—An outline of the mechanical equipment, with special reference to the new 150-ton plate ice plant. A 40-yr.-old poppet-valve engine is still doing good work.

*

The largest brewery in Milwaukee, and dispenser of the famous "beer in brown bottles," has many features of mechanical interest. The equipment for handling the product is of the latest and best, and large plants are required to furnish steam for the various processes, refrigeration for cooling and power to turn the wheels. There are two boiler plants, one having 3900 hp. and the other 2550 hp. in water-tube and return-tubular boilers.

The steam, which is generated at 125-lb. pressure, is used for manufacturing purposes, for heating (which is nearly all live steam) and for driving the engines connected to the ammonia compressors. In the latter department there is a total capacity of 1850 tons of refrigeration in seven units. The compressors are of the Linde type, driven by corliss engines, and two by a German Sulzer poppet-valve engine some 40 years old. The latter is in excellent condition and, from all appearances, is good for many years to come. The engine units are run condensing. Above the compressor room are ammonia condensers of the atmospheric type. Water for condensing is supplied by a pumping station on the

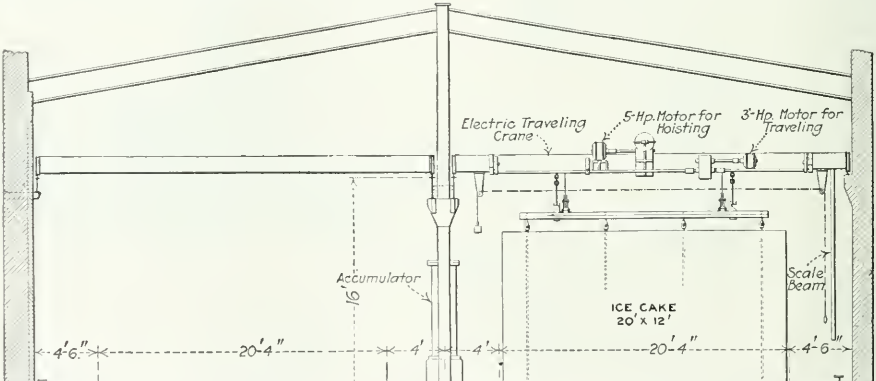


Fig. 1. Transverse Section of Plate Ice Plant

river three blocks distant. There is a 6-million-gal. pumping engine and a 7½-million-gal. centrifugal pump to supply a capacity demand of 3½ million gal. Steam for these units is superheated to 500 deg. The water is first supplied to the ammonia condensers and then passed on to condense the steam.

A total of 500 motors in the brewery, varying in size from ½ to 60 hp., and the lighting are supplied with current from the Commerce St. station of the Commonwealth Power Co. This station also supplies current to various company buildings and for outside commercial use. It will soon have a total capacity of 5500 kw., 2500 kw. in three cross-compound, alternating-current barometric condensing units, and a 3000-kw. turbine now being installed. There is 3000 hp. of water-tube boilers, with special facilities for unloading coal from boats and conveying it from storage to bunkers above the boilers.

Perhaps the most interesting and, at any rate, the latest addition to the mechanical equipment is the 150-ton Vilter plate ice plant; it is in operation the year around, making ice for refrigerating cars and local transportation at a cost not exceeding 70c. per ton. The building is 61x145 ft. and, to the roof trusses, is 36 ft. high. As shown in Figs. 1 and 2, it has two tanks, each 110 ft. 4 in. long, 12 ft. deep, 20 ft. wide at the bottom and 20 ft. 4 in. wide at the top. Three bulkheads divide each tank into four compartments, each containing 10 zigzag coils of 1¼-in. extra heavy pipe. A plate of ice 12x20 ft. and 11 to 12 in. thick forms on each side of a coil, so that the capacity of the plant in seven days, the freezing time, is 160 plates of ice, each weighing 6½ to 7 tons, a total of 1120 tons, or 160 tons per day of 24 hr. if the maximum weight per plate is assumed. Each coil has 175 lin.ft. of pipe and is covered on each side with a sheet-steel plate to facilitate the removal of the ice.

Water for ice making is obtained from wells on the premises 800 to 1600 ft. deep. It is fed into the compartment between the coils and kept in constant agitation by air compressed to 8- or 9-lb. pressure by either one of two motor-driven blowers. To each compartment there are two ½-in. nozzles supplying the air from the sides of the tank near the bottom. In forcing its way to the top, the air keeps the water in motion and frees it from the small quantity of air it usually contains. During the freezing process the impurities and suspended matter are constantly forced toward the center of the compartment and the water receiving the impurities between the two plates can be drawn off at the bottom.

After the plates have been frozen to the desired thickness they are allowed to temper for 6 to 8 hr. The next process is to free them from the steel plates covering the coils and the surfaces of the tank with which they come in contact. These coils are shut off from the low-pressure side and are fed with hot ammonia vapor direct from the compressor. As the vapor is under high pressure, about 175 lb., it forces the liquid ammonia in the coils into the low-pressure system. The coils are then full of hot vapor, and in condensing, this gives up its heat to the surrounding steel plates, which in the course of half an hour are freed from the ice. Steam coils are used to loosen the ice from the bottom and sides of the tank. For every two plates there are 150 ft. of 1-in. pipe. Between the supporting timbers the steam coils are placed next to the ¼-in. steel wall of the tank and are covered with double boards.

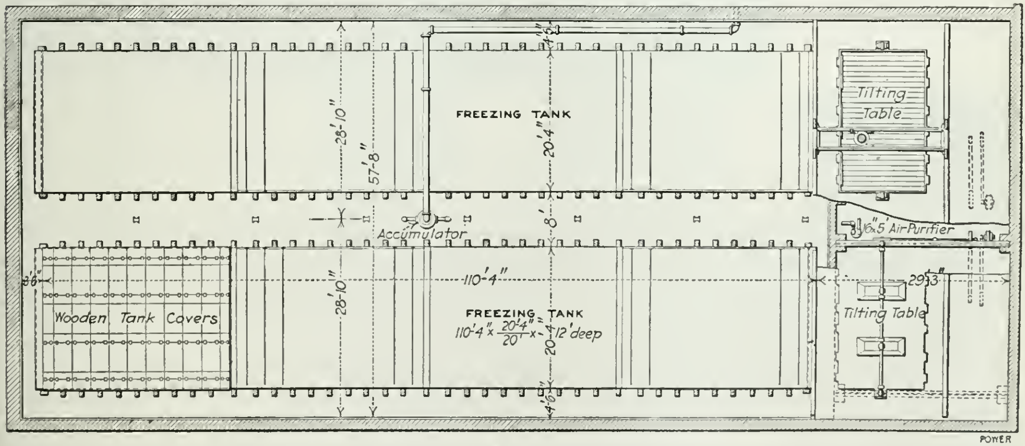


Fig. 2. Plan View, Showing General Layout

When the plate is free, the ice is ready to be harvested. Four hollow tubes frozen into the plate and passing through it to the bottom of the ice afford means of attachment for the hooks of the traveling crane, which hang from a horizontal beam suspended by the hoisting cables of the crane. While suspended as in Fig. 3, the weight of the plate may be transferred to a beam scale and the tonnage recorded. The plate is then conveyed to a cutting table, which may be tilted, as in Fig. 4, to receive the ice, and then lowered to a horizontal position. The lifting rods are thawed out by steam, and the plate, in this plant, is cut into 77 pieces approximately 21 in. square. As shown in Fig. 5, the saw is mounted on a traveling frame kept in motion for the cuts in one direction. For the cross-cuts the saw carriage travels on the frame; the saw is, of course, adjustable to any size of cake. There is a 7½-ton crane and a cutting table for each tank. After the cakes are sawed they are conveyed to storage.

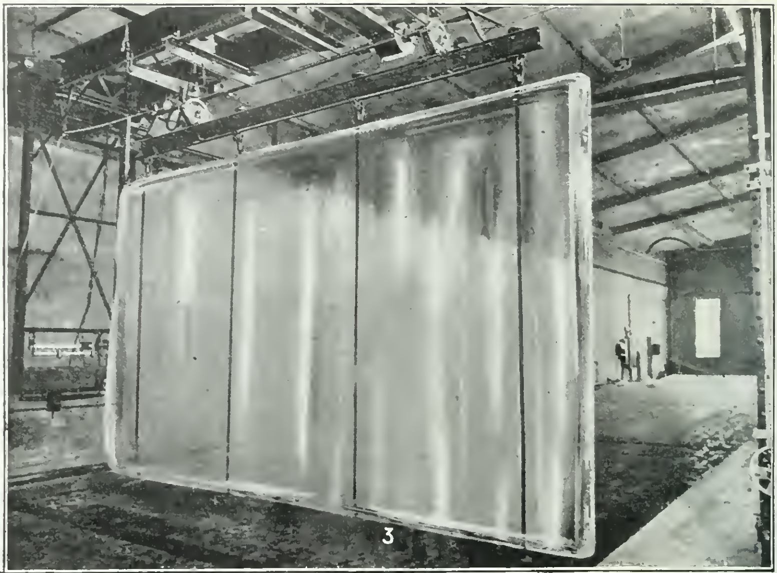


Fig. 3. Plate of Ice Suspended from Traveling Crane

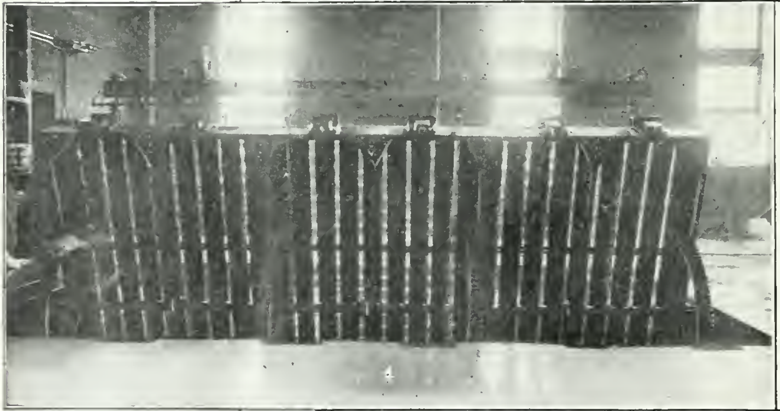


Fig. 4. Cutting Table Tilted to Receive a Plate of Ice

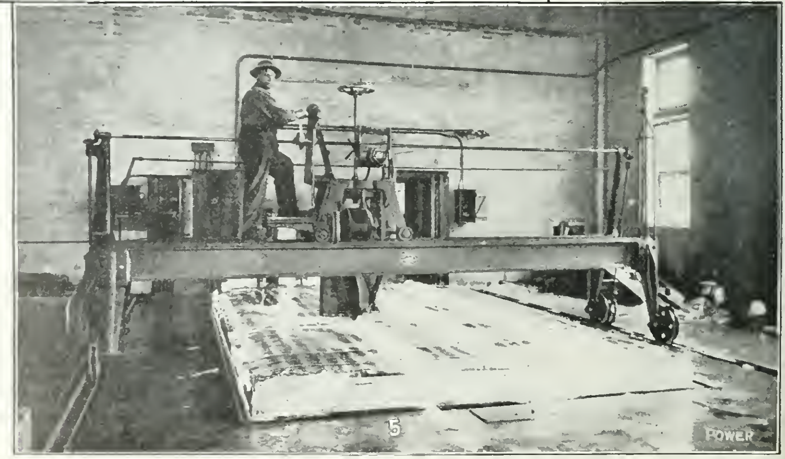


Fig. 5. Sawing the Plate into Cakes

Having followed the product from well to storage, it may be of interest to trace the ammonia. The flooded, or more properly the gravity-feed, system is employed. This entails the use of an accumulator and the coils in the tank are maintained full of liquid. Instead of installing a control or expansion valve on each coil, as in the usual direct-expansion system, and manipulating a large number of valves to regulate the varying demands for ammonia, in this installation one valve controls the entire supply. To illustrate the importance of this arrangement, it is pointed out that while freezing the first inch of ice will require about one hour, and naturally much ammonia per unit of time, the last inch will require about one day to freeze, and consequently about one-twenty-fourth the ammonia required to freeze the first inch.

With 80 valves instead of one, there would be constant need of adjustment, making it practically impossible to regulate the feed in this way. With the gravity-return system, just the amount of ammonia needed is evaporated. There is not so much necessity for regulation; an occasional turn of the one valve toward closing is the requirement to meet the decreasing demand.

A 300-ton compressor serves the ice plant. Liquid ammonia under high pressure is conveyed through a 2-in. pipe a distance of 1000 ft. This ammonia passes through a spiral coil in a chamber on top of the accumulator and is cooled by the suction vapor on its way to the compressor. Cooling the liquid to the temperature of the ammonia in the coils prevents it flashing into a fog-like mist in the accumulator, which would be carried along with the return vapor and cause trouble in the machine. From the cooling coil, the liquid ammonia enters the body of the accumulator and flows by gravity to the inlet header at the bottom of the coils. The liquid in the accumulator is maintained at the same level as the outlet header of the coils, so that the latter are kept full of liquid and their entire surface made effective. From the outlet header ammonia vapor passes off to the suction of the compressor.

In its passage through the accumulator cooling chamber the entrained liquid is retained by baffles much in the same way as in a steam separator and returned to the body of the accumulator. Thus, the feed to the coils is made up of a mixture of the liquid returned from the separator and the fresh supply from the high-pressure side. The one control valve previously mentioned is in the pipe connecting the cooling coil in the separator with the body of the accumulator.

With the arrangement described, a large number of coils may be fed in parallel. The simplicity of this arrangement and the facilities for harvesting the ice reduce the labor in the plant so that only two men are required. The initial cost of the system is comparatively high, but this is offset by the reduction of labor in harvesting, by the efficiency of the plant, the high quality of the product and the simplicity of operation.

*

Water-Power Developments in California to the total construction cost of $5,941,300 have been sanctioned by the state water commission, according to a recently issued report, during the two years ended Apr. 1, 1914. Since Jan. 1, 1913, twenty-one out of thirty-eight applications to appropriate water have been rejected, according to the report, either for failure to comply with rules prescribed by the commission or on the ground that the interests of the state demanded such arejection.

"Gasteam" Engines at Ford Plant

Much interest is being shown and many questions asked regarding the new power plant being built by the Ford Motor Co. at Highland Park, Detroit. This will be a combination gas and steam plant, equipped with steam boilers, gas producers and "regenerators," provision being made to utilize as much of the waste heat as possible. Each main unit, of which there are four, will consist of a two-cylinder gas engine arranged in tandem and a tandem compound condensing steam engine. These will be connected to one shaft, similar to the arrangement employed in a cross-compound steam engine, and will drive a 3750-kw. 250-volt direct-current generator at 80 r.p.m. Each unit will be capable of developing 6000 brake-horsepower.

This combination "gasteam" engine will give the economy of a gas engine and the reliability of a steam engine. Gas engines, as a rule, operate at their best when fully loaded and with a constant load. However, if operated in this manner they have no overload capacity, which results in the practice of running them underloaded. This produces wire-drawing of the gases through the valves and ports, which has a tendency to precipitate tarry matters but usually does not give trouble under full-load conditions. With the combination type of unit the engine is not intended to be put in service, unless there is a half-load or more, hence the gas side will always be fully loaded. There has been no attempt to govern the gas side other than in cases of over speeding. The steam side will do all the governing and take care of all the load fluctuations. In case of trouble on the gas side, the steam side can pull the entire load with a late steam cutoff.

The engines will be of the four-stroke-cycle, double-acting type with water cooling. Each cylinder will be 42 in. in diameter and 72-in. stroke, the same size as those of the big Ford engine installed last year; see Power for July 22, 1913.

The tandem-compound condensing steam unit will have a high-pressure cylinder 36 in. in diameter and a low-pressure cylinder 68 in. in diameter with a stroke of 72 in. The low-pressure cylinder will be connected to a surface condenser which in turn will be placed in a closed heating system. The vacuum will be regulated to correspond to atmospheric temperatures and during the winter months it will be reduced to about 18 in. and the entire amount of circulating water will be pumped through all the factory buildings for hot-water heating. Superheated steam will be used at a pressure of 175 lb. and the high-pressure cylinder will be equipped with poppet valves, while Corliss valves will be employed on the low-pressure cylinder.

Exhaust from the gas engine will be conducted into a steam superheater located in the steam line between the high- and the low-pressure cylinders, thus utilizing waste gases for reheating the high-pressure exhaust steam. Part of the exhaust gases are shunted through the jacket of the high-pressure cylinder for the purpose of eliminating heat losses in that cylinder. The exhaust gases are then conducted to the boiler feed-water heater and will heat all the feed water required for the steam boilers.

Feed water for the heater is secured from the water used for cooling in the gas cylinder jackets, where it is brought up to a temperature of from 150 to 180 deg. This is finally raised to a temperature of about 250 deg. in the heater by means of the exhaust gases, as previously mentioned.

It is also planned to arrange the batteries of boilers and producers in such a way that the producer gas may be passed through some of the boilers on its way to the scrubber and thus utilize much of the sensible heat for steam generation. Of course, the relatively low temperature of the producer gas will prevent forcing a boiler in this way, and it has been suggested that provision be made for burning some of the gas in the furnaces when necessary.

The engines are being furnished by the Hooven, Owens, Rentschler Co., of Hamilton, Ohio, who built the two earlier gas engines for the Ford Co., while the Crocker-Wheeler Co. is furnishing the generators and Wickes Bros. the boilers.

New Engineering Bureau for N. Y. Board of Education

It is understood that the board of education of the City of New York is about to give final consideration to the proposal that a new bureau of engineering be created, with a mechanical engineer as its executive head, to care for all engineering matters in connection with the public school buildings of that city.

For such a new bureau to go into effect in 1915, action must be taken at once for inclusion in the 1915 departmental budget. Otherwise, it must lay over for another whole year. This matter has been under consideration for a long time, in one form or another, and it is to be hoped that it has now reached a settlement.

REASONS FOR THE NEW BUREAU

At the present time engineering matters in the board of education are being handled by three separate bureaus and by many officials. The design of engineering equipments for new schools is handled by the building bureau, whose head is an architect. Under him are consulting sanitary, electric and heating engineers, each in charge of his specialty, but limited by the superior authority of the architect, head of the bureau. In the matter of installation, these designing engineers are further limited by the authority of the several deputy superintendents of school buildings, one for each of the five boroughs into which the city is divided. These deputies are also architects.

In the matter of repairs and maintenance of engineering installations, the designing engineers have almost nothing to say as the deputy superintendents of school buildings control the expenditure of all repair funds in their respective boroughs, in most cases without consultation with the designing engineers, and the several engineering inspectors, while nominally under the respective designing engineers, are actually controlled by the respective deputy superintendents. Supervision of janitors and of the operation of the heating plants, etc., is handled by a separate bureau, headed by a supervisor or janitors assisted by three assistant supervisors.

There are nearly 700 schools in the city and it is evident that these four men cannot adequately supervise the janitors, engineers, cleaners, etc., employed in these buildings. Cleanliness of the buildings is the most prominent feature of the janitorial service and as all the boilers, etc., are hidden away from view in the cellars, the latter receive but little supervisory attention hence conditions obtain which are likely to lead to unsatisfactory and uneconomical operation of the plants.

At the present time, engineering conditions in the New York City schools are in a bad way, and it is easy to understand the causes of the many criticisms of their heating and ventilation.

The Board, in its present consideration of this matter, will undoubtedly realize the necessity for divorcing engineering from architectural supervision and for consolidating, under one competent mechanical engineer, all classes of engineering, including power plants, heating and ventilating, electric and sanitary engineering, together with the selection and supervision of the operating engineers and janitors handling such installations. With such a bureau of engineering, handling all engineering matters under one head, there would be possible undivided economical operation of plants, adoption of the best practice in design and wise expenditure of repair funds, with consequent savings in costs of fuel and inspection, and more satisfactory conditions in the schools as to sanitation, ventilation, etc.

The New York Chapter of the American Society of Heating and Ventilating Engineers, at a recent meeting, unanimously passed resolutions favoring the creation of the proposed new bureau, which resolutions were transmitted to the board of education.

Chicago to Help N. A. S. E. Delegates On Their Way

To show their hospitality and to render any service possible to delegates and visitors stopping over at Chicago on their way to the National Convention at Milwaukee, Locals Nos. 1, 2, 28 and 38, N. A. S. E., of Chicago, have secured quarters at the Fort Dearborn Hotel, Van Buren and La Salle Sts. Here a committee from the joint associations, assisted by the ladies' auxiliaries of Chicago, will hold open house and do their best to welcome and entertain incoming conventioners.

Members of the committee will be in constant attendance on Saturday, Sunday and Monday preceding the convention, and will be glad to meet any or all delegates at the train. All that will be necessary is a postal to Al. Johnson, chief engineer of Mandel Bros., Chicago, Ill. The hotel is central and has a wide range of prices, so that reasonable accommodations may be secured. A hearty welcome is assured to all, and it is the hope of the committee to greet a large delegation.

PERSONALS

Charles C. Hughes has succeeded S. A. Bockius as general Western sales agent for the Elliott Co. and the Liberty Mfg. Co. His headquarters are 1542 Monadnock Block, Chicago, Ill.

William De Groot, Grand Rapids, was elected doorkeeper at the recent annual state convention of the Michigan N. A. S. E., instead of Edward Rose, Detroit, as stated in the Aug. 4 issue.

J. M. Smith, for 13 years a member of the engineering corps of the Crocker-Wheeler Co., has accepted the newly created position of engineering manager at the Triumph Electric Co.'s works, Cincinnati (Oakley), Ohio.

Frank H. Ball, who has been connected with the high-speed engine business as inventor and manufacturer since its infancy, has withdrawn from that field to engage in the manufacture and sale of carburetors. Associated with him under the firm name of Ball & Ball, at Detroit, is his son, Frederick O. Ball, until recently general manager of the American Engine & Electric Co.

NEW EQUIPMENT

WEST OF THE MISSISSIPPI

Bids will be received until Sept. 7, by the City Council, Alvord, Iowa, for constructing a municipal electric-light plant.

The Central Light & Power Co, Boone, Iowa, will build an electric-light plant in Dayton, Iowa.

Press reports state that bids will be received by the city of Topeka, Kan., until Oct. 1, for installing in the municipal electric-light plant, a 250-kw., 60-cycle, three-phase, 2300-volt turbo-alternator with exciter.

A municipal electric-light system will be constructed at North Bend, Neb. The estimated cost is $21,000.

Bids will be received by C. L. Jones, City Audr., Parker, S. D., until 10 a.m., Sept. 4, for constructing an electric-light plant. The work consists of a power station, oil engines and accessories, generators, exciters, etc., and a pole line and wiring. J. F. Druar, St. Paul, Minn., is Consult. Engr.

F. H. Mudd, Maben, Mo., has been granted a franchise to construct an electric-light plant. He is in the market for machinery.

Carl Shipp, Winnsboro, Ark., is in the market for equipment for his electric-light plant, which will be enlarged.

Bonds for $100,000 have been voted by the citizens of Mangum, Okla.; the proceeds will be used to equip an electric-light and power plant.

The Salt Lake Light & Traction Co., Salt Lake City, Utah, has been organized with a capital of $1,000,000, to establish power plants and distributing systems. O. J. Salisbury is Pres.

The San Joaquin Light & Power Co., Merced, Calif., it is reported, will double the capacity of its gas plant and will install new generating machinery. A. G. Wishon, Fresno, is Gen. Mgr.

POWER

Vol. 40 NEW YORK, SEPTEMBER 8, 1914 No. 10

Virtue Is Its Own Reward

AFTER ALL, unselfishness is the best kind of selfishness. It pays. To do your best for somebody else is generally the best way to do the best for yourself.

If you can show the boss how to save money or get better results, you will have a heavier load of a pay envelope to carry home or else he is the wrong kind of a boss and you had better look out for a new one.

If you tell the boss you'll do more work if he'll give you more money, you probably won't increase your deposits in the savings bank. But if you do more work first, you have a right to demand more money and you don't have to ask for it as a favor.

Most bosses come from Missouri and if you know enough geography to show them the map, they'll come across the border.

Work and the world is with you; loaf and you're left alone. [*By Hugh Molleson Foster, New York.*]

Waterside Station, Louisville Gas & Electric Co.

By Warren O. Rogers

SYNOPSIS—The most interesting feature is the condenser pit, 53 ft. deep and 30 ft. in diameter, in which are the vertical surface condensers and circulating and house-service pumps. The piping is arranged to dispense with all steam traps. An indicating panel in the boiler room, controlled by the switchboard operator in the turbine room, notifies the firemen when a machine is to be started and also the load being carried.

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About one year ago H. M. Byllesby & Co. effected a consolidation of the five electric and two gas companies which had hitherto been operated separately in Louisville, Ky. These plants are now operated by the Louisville Gas & Electric Co.

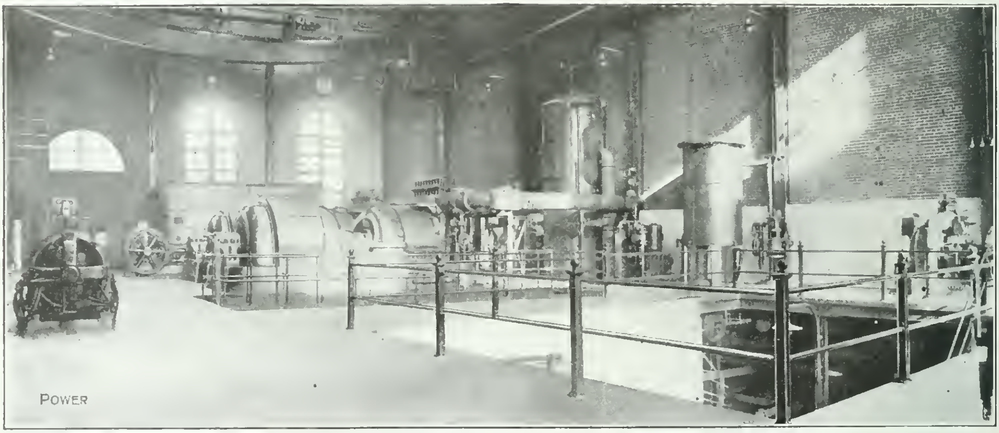


Fig. 1. Turbine Room of the Waterside Station of the Louisville Gas & Electric Co.

The Waterside station, formerly belonging to the Kentucky Electric Co., and the 14th Street station of the former Louisville Lighting Co., are connected by tie lines and supply electrical energy for the city and suburban territory, the other smaller plants being shut down. The Waterside station, on the river front, is the more modern, having been built about eighteen months ago. Although there is but one 2000- and one 4000-kw. turbine unit, the station is designed for an ultimate capacity of 64,000 kw. At the present time extensive additions are in progress of construction.

The two turbines, Fig. 1, are housed in a building 134 ft. wide by 107 ft. long. The building is three stories high, exclusive of the basement, and the boiler and the turbine-room floors are on the same level. The two galleries on the left side of the turbine room are devoted to switch and busbar compartments and to lightning-arrester apparatus.

Condenser Pit

An interesting feature is the arrangement of the condensers in a pit 52 ft. 3 in. below the turbine-room floor and 30 ft. in diameter. This arrangement was made necessary by the 45-ft. rise and fall in the stages of the Ohio River at the plant site. The well is built of concrete, with walls 4 ft. thick. The barrel-shaped intake and discharge tunnels, Fig. 2, are below the bottom of the condenser well, and are 8 ft. long and 7 ft. high at the center. Water is taken from the river through a concrete screen well which is 535 ft. from the two concrete intake cribs, 75 ft. apart, and carried through two cast-iron flanged pipes with flexible joints. From the river waterline 42-in. concrete pipes extend to the screen well, made with two compartments, each connecting with a 42-in. supply pipe; the screens are placed diagonally across each compartment, Fig. 3. The well is connected to the condenser pipe by concrete intake tunnels, Fig. 2. The top of the upper tunnel is between four and five feet below the average low-water mark, and the siphon principle assists in circulating the cooling water through the condensers. Either tunnel can be used as an intake or discharge by means of valves arranged in the pipes leading to the river. By reversing the flow, any sediment that collects can be washed out.

Fig. 4 is a view of the condenser pit taken from the turbine-room floor. There are two specially designed vertical, double-pass condensers, each with 10,000 sq.ft. of cooling surface. The No. 18 gage tubes are 1 in. in diameter and 14 ft. 9 in. long. Each condenser is capable of taking the steam from a 4000-kw. turbine and is connected to its turbine by a 60-in. pipe which enters the condensers at the side. The 8-in. air pipe is taken out at the opposite side and extends up to the 14 and 8 by 18-in. dry-air pumps at the back of the 2000-kw. turbine, as in the plan view, Fig. 10. The 20-in. tri-rotor circulating turbine-driven pumps are each capable of delivering 9000 gal. of water per minute against a 15-ft. head. There is also a 4-in., two-stage hotwell pump on the end of each circulating-pump shaft, with a capacity of 200 gal. per min. The general arrangement and details of the condensers, pumps and piping in the condenser pit are shown in Fig. 5. The 20-in. suction pipe from the intake tunnel terminates at an angle valve at the top and the short 20-in. discharge pipe enters the condenser through the bottom head.

In order to determine the condition of the screens in the intake well, floats have been placed in the tunnels and connected to graduated indicating tapes so brought up through vertical pipes that the operator on the turbine-room floor can determine by the gage reading the difference in the water level in the pipe, which corresponds to the friction head required to force the water through the screens and tunnel. It is contemplated to so improve this device that recording chart records may be made.

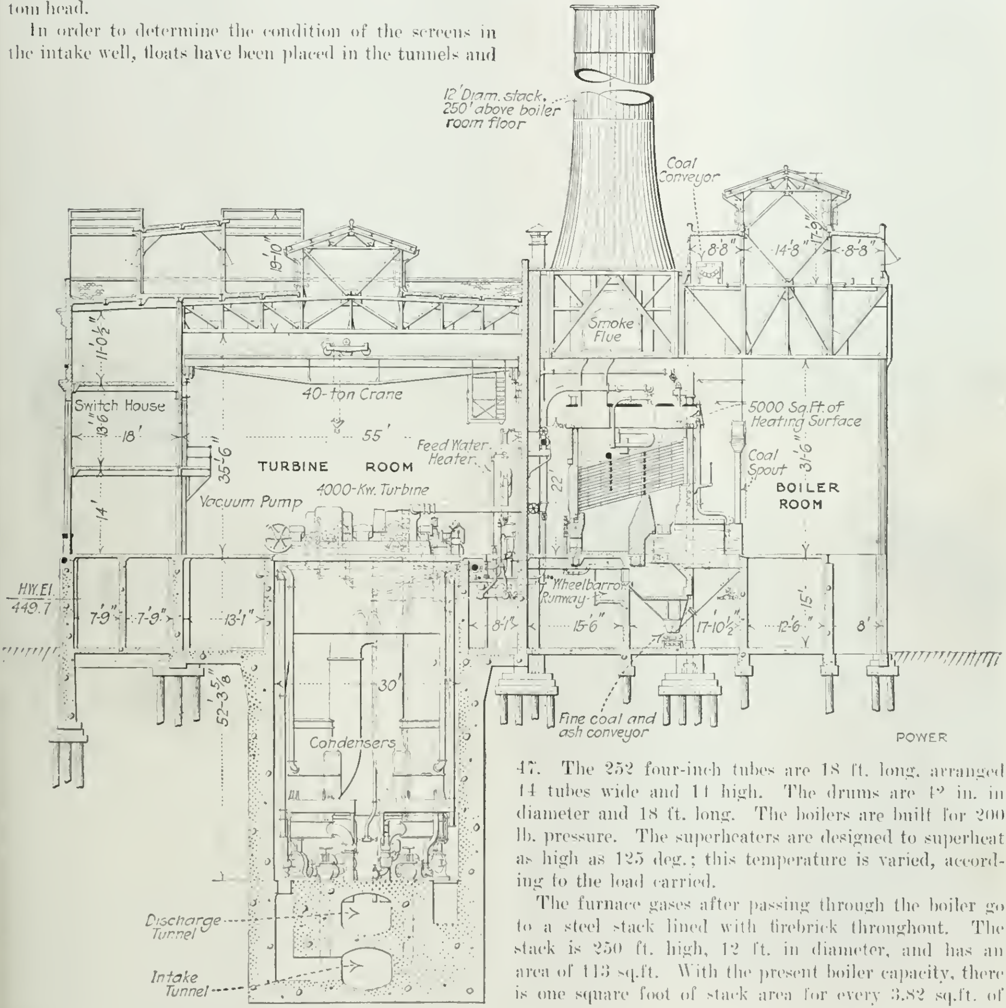


Fig. 2. Elevation of the Power Plant, Showing the Condenser Well

Boiler Room

The four water-tube boilers are arranged in batteries of two, in a single row, with room for two more in the same row, and when the proposed extensions are made there will be room for six additional boilers in a second row opposite with a 30-ft. firing aisle between. The present 500-hp. boilers, Fig. 6, each having 5087 sq.ft. of heating surface, are equipped with chain-grate stokers, each having a grate area of 108 sq.ft., or a ratio of 1 to 47. The 252 four-inch tubes are 18 ft. long, arranged 14 tubes wide and 11 high. The drums are 42 in. in diameter and 18 ft. long. The boilers are built for 200 lb. pressure. The superheaters are designed to superheat as high as 125 deg.; this temperature is varied, according to the load carried.

The furnace gases after passing through the boiler go to a steel stack lined with firebrick throughout. The stack is 250 ft. high, 12 ft. in diameter, and has an area of 113 sq.ft. With the present boiler capacity, there is one square foot of stack area for every 3.82 sq.ft. of grate surface, or one square foot of stack area for each 17.7 boiler-horsepower rating. When the other two boilers are placed, the ratio of stack area to boiler-horsepower will be as 1 to 26.5. The stack is supported by steel beams, so that the bottom is above the turbine-room roof; Fig. 2 shows the arrangement and the smoke flue. The brick lining is 4 in. thick at the top and 6 in. at the bottom. To prevent corrosion, grout is used between the brick lining and the steel shell.

Feed water is supplied by three turbine-driven, 4-in., 4-stage turbine pumps discharging against a head of 225 lb., with a capacity of 450 gal. per min.; these pumps are in the basement under the turbine room. The hot-well water for boiler feed and all makeup water in the

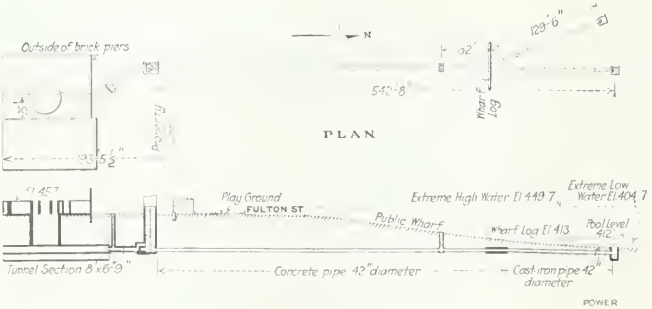


Fig. 3. Profile and Section through East Pipe

jackets of the dry-vacuum pumps and turbine bearings is passed through filters.

Although coal is now delivered by rail, the plant is so located that when arrangements have been made, it can be received by boat. It is dumped into concrete bunkers below a spur track and then hoisted by a 1.5-cu.yd. clamshell bucket and emptied into a set of crushing rolls on the roof. The crusher has a capacity of 65 tons per hour. If the coal does not require crushing, it is delivered to a 24-in. belt conveyor running over the 50-ton capacity bunkers. The hoist is operated by a 112-hp. motor, the crusher by a 30- and the conveyor by a 5-hp., 220-volt, three-phase induction motor.

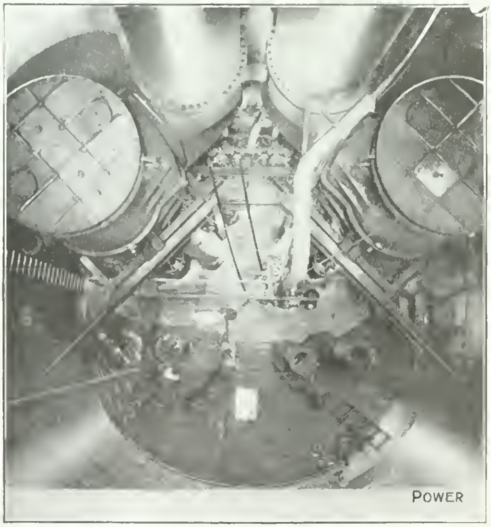


Fig. 4. View of the Condenser Well from the Turbine-Room Floor

The boiler ashpits are made in two compartments, one for the fine coal sifting through the stokers and the other for the ash. Under the hoppers is a 30-in. conveyor belt for handling either the ash or fine coal sifting. The ashes are discharged into a concrete ash bin outside of the plant, from which they are loaded into railroad cars by the coal-hoist bucket.

Steam from the superheater of each set of two boilers is piped to a 10-in. lead connecting with a 12-in. steam header next to the wall in the boiler room. From this header a 10-in. branch line goes to each main turbine. Expansion loops, placed horizontally over the boilers, relieve the pipe system from strains.

Feed water is supplied through either the main 5-in. header or the 5-in. auxiliary boiler-feed line; both are piped to the boiler-feed pumps. Exhaust steam from the pumps and auxiliary turbines is piped to a main feed-water heater in the turbine room. All steam traps have been eliminated by drains arranged for the high-pressure steam mains. The main header and the 10-in. supply pipes to the main turbines drop 12 ft. and pass in through the separating wall to the tur-

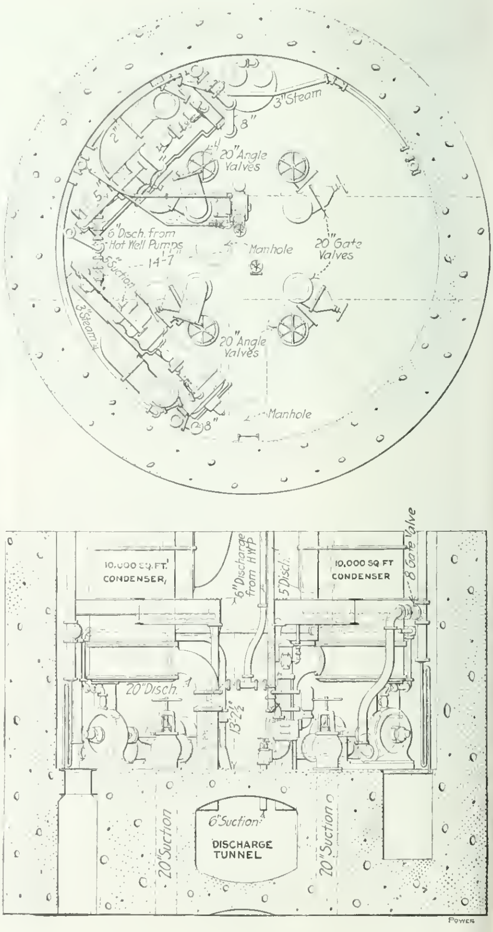


Fig. 5. Plan and Elevation of the Condenser Well

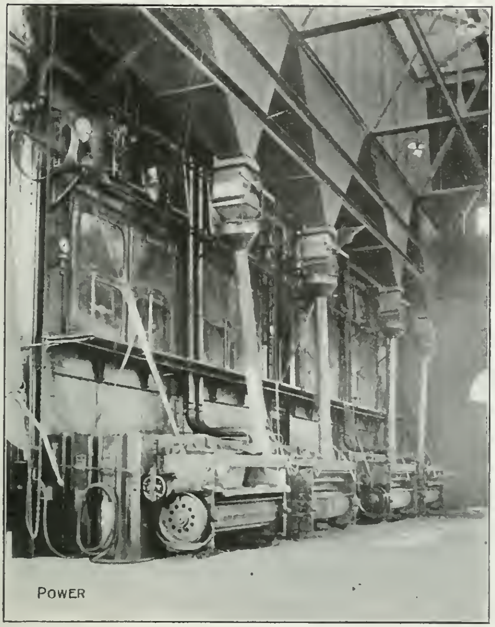


Fig. 6. Four 500-Hp. Water-Tube Boilers

bines. A 3-in. pipe connects with the bottom of the elbow, where the 10-in. pipe makes the turn and is carried to the house pumps in the bottom of the condenser well. All supply-pipe lines to the auxiliary units are taken from the top of the auxiliary header. From the bottom, two connections are taken from the under side of the header and piped to the reciprocating house pumps at the bottom of the condenser well. By this arrangement, Fig. 7, all water of condensation goes to the service pumps and is disposed of through the exhaust to the heater.

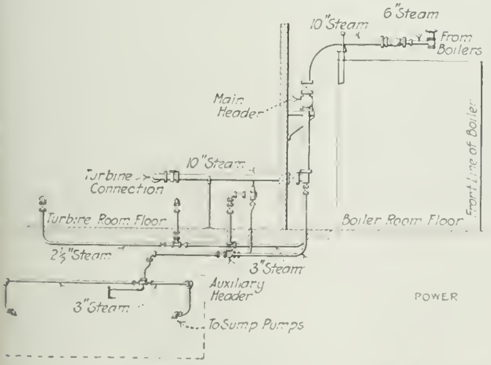


Fig. 7. Piping Arrangement to Eliminate Steam Traps

Boiler-Room Indicator

An interesting indicating system has been arranged whereby the operator can signal to the fireroom the load to be carried, thus giving information of the amount of steam required at any time.

The system has an indicating panel, Fig. 8, in the boiler room, where it can be seen from the firing aisle by the firemen. The casing is 6 ft. high and 1 ft. wide. The panel face is numbered from 500 to 4500 kw. at 500-kw. intervals. Back of the face are incandescent lamps which illuminate the load number to be carried by the turbines. The lamps are connected to an operating switch, Fig. 9, at the switchboard in the turbine room, the switch being a handle with a sliding contact which can be brought over any one of the 12 buttons, or bridge any two buttons, if desired.

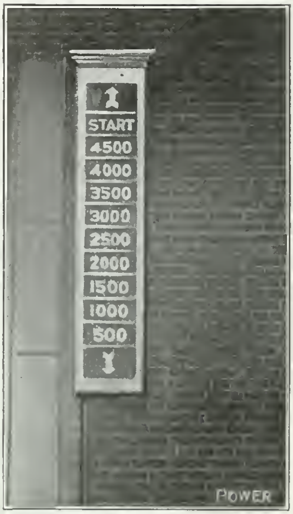


Fig. 8. Indicating Board

Each button corresponds to a panel on the signal load. When the handle is placed at, say, 3000 on the switch, the lamp back of the corresponding figure on the indicating board is lighted. If the load is between 3000 and 3500 kw., the two corresponding contacts are bridged by the handle, thus lighting both indicator panels. Should it be necessary for the operator to start a second turbine, the switch handle is moved to the "start" contact before the machine is started up. In conjunction with the signal panels there is a return call bell controlled by three-way switches.

In case the fireman is in doubt as to the load being carried, due to the operator's failure to change the panel, a three-way switch is pushed which lights up two arrows similar to those shown at the top and bottom of the indicator, on the desk board. The operator then either

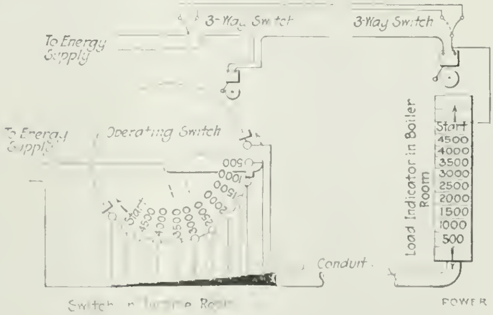


Fig. 9. Connections of Call Bell and Indicator Mechanism

changes the indicator according to the load carried or lights up one or the other of the arrows in the boiler room, indicating that the load will either increase or decrease.

Auxiliary Electrical Units

Exciting current is supplied to the main generators by a 100-kw. turbine-driven, 125-volt generator at 2400 r.p.m., or by a 150-hp. motor driving a 100-kw., 125-volt direct-current generator at 900 r.p.m. There is also a 5.5-kw., 220-volt motor generator for supplying energy for charging the storage batteries used for switchboard control.

One 500-kw. synchronous motor-generator set, in the turbine room, furnishes 600-volt direct-current service. This set is operated by 6600-volt, three-phase energy and supplies current at 600 volts for the commercial motor circuits. It is designed for 70 per cent. power factor correction.

At the north end of the plant is the operating engineer's office. The switchboard is at the side of the building at the opposite end of the turbine room.

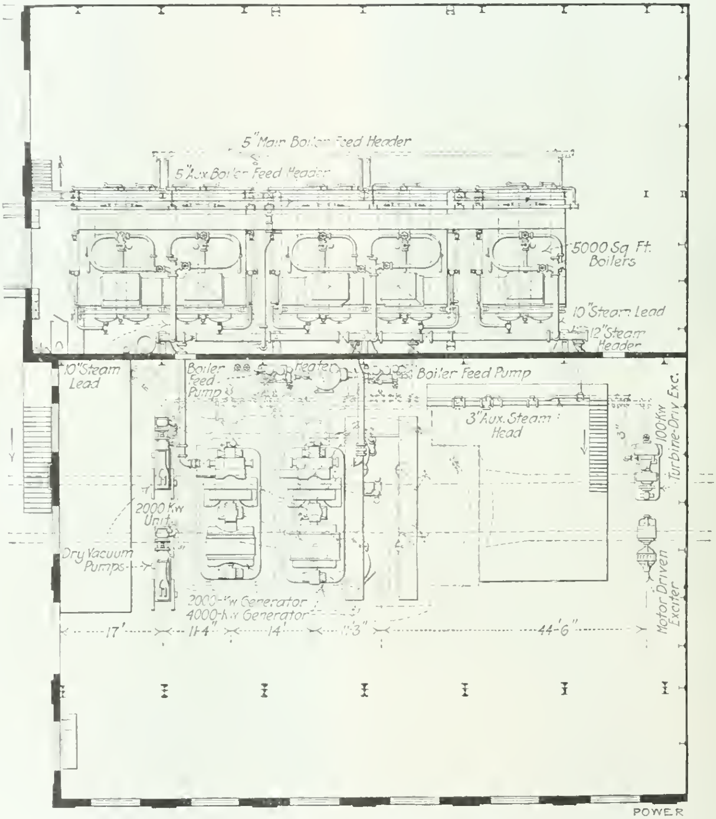
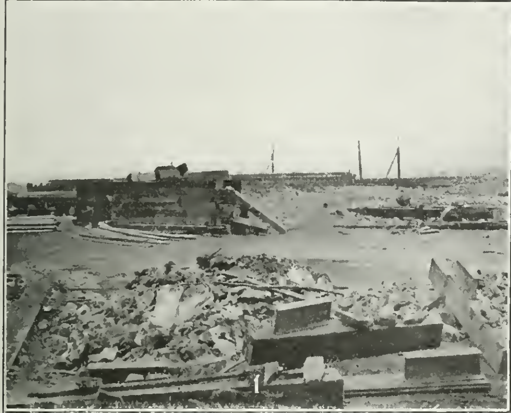


FIG. 10. PLAN OF THE WATERSIDE POWER STATION

PRINCIPAL EQUIPMENT OF STATION B (WATERSIDE) OF THE LOUISVILLE GAS & ELECTRIC CO.

No	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-generator	Curtis, G. E.	2000 kw.	Main units	1800 r.p.m., 2300-4600 volts, 175 lbs. steam	General Electric Co.
1	Turbo-generator	Curtis, G. E.	4000 kw.	Main units	1800 r.p.m., 2300-4600 volts, 175 lbs. steam	General Electric Co.
2	Condensers	Surface	10,000 sq. ft.	With turbines	28-29 in. vacuum	Alberger Pump & Cond. Co.
4	Boilers	B. & W.	500 hp.	Steam generators	185-lb. steam, 125 deg. superheat	Babcock & Wilcox
4	Superheaters	B. & W.	500 hp.	Steam boilers	125 deg. superheat	Babcock & Wilcox
2	Pumps	Dry air	14x8x18-in.	On condensers	Separate, with interconnection	Alberger Pump & Cond. Co.
2	Pumps	Circulating tri-rotor	20-in., 9000 gal. capacity	With condensers	Work against 15.-ft. head	Alberger Pump & Cond. Co.
2	Turbines	Single stage	200 hp.	Driving tri-color pumps	1300 r.p.m., 185 lb. steam	Alberger Pump & Cond. Co.
2	Pumps	Single-stage	4-in.	Hot well	Mounted on shaft of circ. pump	Alberger Pump & Cond. Co.
1	Chimney	Steel, brick lined	250 ft. high, 12 ft. diam.	Furnace gases	Natural draft	Kennicott Co.
3	Pumps	Four-stage	4-in.	Boiler feed water	9700 r.p.m. turbine driven	Alberger Pump & Cond. Co.
1	Turbine	Single-stage	150 hp.	Driver boiler feed pump	9700 r.p.m., 185 lb. steam	General Electric Co.
2	Turbines	Single-stage	150 hp.	Driving boiler feed pumps	2700 r.p.m., 185 lb. steam	Terry Steam Turbine Co.
1	Coal hoist	Clamshell bucket	1.5 cu. yd. cap.	Hoisting coal	Intermittent	Orton & Steinbrenner
1	Crusher	Coal	65 tons per hour	Crushing coal	Intermittent, by motor	Orton & Steinbrenner
1	Conveyor	Belt	30-in.	Ash or fine coal sifting	Intermittent	Robins Belt Conveying Co.
1	Turbo-generator	Steam, D.c.	100 kw.	Exciter unit	185 lb. steam, 125 volts, 2400 r.p.m.	General Electric Co.
1	Motor-generator	A.c., D.c.	150 hp., 100 kw.	Exciter unit	900 r.p.m., 125 volts	General Electric Co.
1	Motor-generator	A.c., A.c.	5.5 kw.	Charging storage batteries	Intermittent, 220-volt	General Electric Co.
1	Motor-generator	Synchronous	500 kw.	Power service	600-volt	Westinghouse Elec. & Mfg. Co.
1	Feed water heater	Open, 5" back pressure	2000 hp.	Boiler feed water	Continuous	Platt Iron Works Co.
1	Crane	Electric, A.c.	40 tons & 5 tons	Turbine room equipment	220 volt, A.C., intermittent	Northern Crane Co.

Refuse from Intake Tunnel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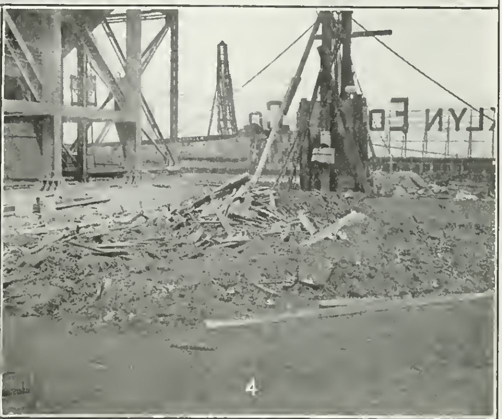
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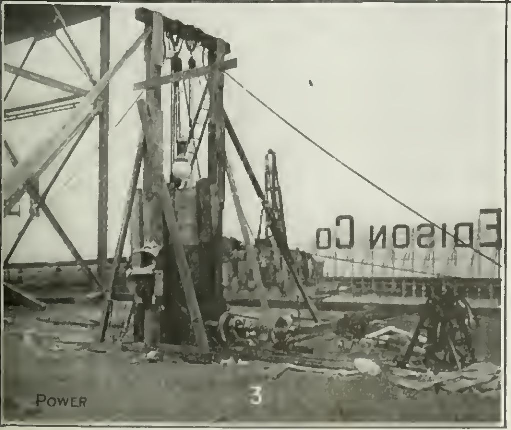

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Refuse from Intake Tunnel

The photographs, Figs. 1, 2, 4 and 5, show refuse taken from an 8x8 ft. condensing-water intake for the Sixty-sixth Street station of the Edison Electric Illuminating Co. of Brooklyn, N. Y. The refuse represents an accumulation of about eight years.

To clean the tunnel the entrance was closed by the winch-operated gate, Figs. 3 and 4, and a small motor-driven centrifugal pump used to empty it and pump out the leakage. Notice the heavy timbers in the foreground of Fig. 1. These timbers had long heavy bolts, I-beams and stones fastened to them, evidently to keep them submerged. The accumulation is chiefly wood and mud, tons being taken out. The cleaning was done on Sunday while the station load was carried by the Gold Street station.

Durability of Iron and Steel Pipe

By William Hirst

SYNOPSIS—Suggests reasons why steel pipe sometimes corrodes faster than the wrought-iron. Points out the tendency to overlook the differences of compositions of metals in pipe subject to test, thus lowering the value of test results.

⁂

Manufacturers of steel pipe maintain that there is no difference in the durability of iron over steel pipe, yet, while favoring the use of steel because of its strength and uniformity, the writer's experience—extending over twenty-six years in rolling mills, where both metals were in process of manufacture, and eight years in a rubber manufacturing concern using iron and steel forms—teaches him that there is a substantial difference.

Years ago, when steel shapes were being introduced, it was noticed that steel exposed to the weather rusted rapidly and soon became unsalable, while iron suffered comparatively little. The iron, being rolled at a much higher temperature, formed a thick coat of scale over its surface which undoubtedly protected it, but, aside from that, it was found that iron was less oxidizable than steel.

During the eighties a man approached our firm with a proposal to make wire door mats. It was suggested that his idea was impracticable because the steel ordinarily would be a mass of rust in a few weeks. He showed, however, that he had a steel that was practically rustless; it subsequently proved to be heavily alloyed with nickel, dispelling the idea that steel could not be made as rustless as iron.

Kent states on page 674 of his handbook: "The resistance to corrosion increases with the percentage of nickel up to 18 per cent. This alloy is practically incorrodible." Of course, an alloy that high is impracticable, but it shows what can be done. There are other alloys which tend to make steel better in this respect, and it seems remarkable, in view of the possibilities, that steel should be more corrosive than iron.

The question of the durability of iron and steel pipe has been discussed until it would seem that the subject was exhausted. Tests have been made in laboratories and other places to determine which was the least affected by corrosive elements in the fluids passing through or over iron and steel. The results are not conclusive; they sometimes favor one, sometimes the other, and thus the user is left to his own judgment. There may be, and doubtless is, steel pipe made that will rust as little as iron, but it can be safely stated that the general run of steel pipe is inferior to iron pipe not only in this respect, but in the perfection of its weld and its workable qualities in the dies.

As used in the manufacture of pipe, steel is undoubtedly purer, more homogeneous and has greater strength and ductility in the softer grades of steel from which pipe is made. It is of one kind, one degree of ductility and one hardness. Iron is fibrous, it is often made up of bars of scrap, and it contains more or less foreign matter between the layers. Knowing this, it seems anomalous that iron pipe should be preferred to steel. If it were a matter of strength alone, steel would best meet the requirement, but strength is often secondary; the ability of the metal to resist the corrosive action of the fluids in contact with it is the prime consideration.

As to which is the least oxidizable and will last the longer without grooving, many prefer iron, and that, too, without prejudice. Users decide for one or the other according to their experience, and this is the best way.

Iron has been found to resist the scoring and corrosive action of the discharge from vulcanizers where some kind of acid is generated by the steam from the compounds used in making rubber goods. It has also been found to last longer than steel when used for open returns carrying condensate and vapor from heating coils. In the former case, the discharge from these vessels will cut through the partition in a brass globe valve in a comparatively short time; an iron-body gate valve will outwear them, but an iron asbestos-packed cock is best. With experience like this and with better prices urging the use of steel pipe, we naturally ask, what is there in iron that enables it to resist the destroying elements better and longer than steel?

We are told that chemically pure iron exists only as a curiosity in the metallurgist's laboratory, and that as a pure metal it cannot be considered as a substance of practical importance. With certain metallic or nonmetallic substances with which it is found, or which are added as alloys, however, it becomes useful for an infinite variety of purposes. When we consider that, no matter to what process of refining the products called iron or steel may have been subjected, their base is iron, they are alike, and whatever difference there may be in the products it is due to composition, to the process of manufacture, or to both.

If either has an advantage, we may safely assume that it is the presence of substances chemically combined. Wrought iron commonly contains sulphur, phosphorus, silicon, carbon and cinder or slag. In an analysis of a good wrought iron, the cinder and silica predominate. These may be said to be noncorrosive substances, and there is no doubt that whatever degree of superiority wrought iron may have over steel, it is due to the presence of these substances. The total percentage of impurities in a good grade of iron is given at 1.345, of which 1.168 is cinder, 0.067 phosphorus, 0.065 silica and 0.045 carbon. Here we have a noncorrosive agent or agents more or less evenly distributed throughout the mass, protecting, in a measure, the particles of pure iron.

An analysis of soft bessemer steel is given as containing a total of 0.605 per cent. of impurities, the amount of silica being 0.135, carbon 0.126; cinder not mentioned. An analysis of open-hearth steel shows a still greater degree of purity, the total impurities being 0.385, of which carbon is 0.167, silicon 0.023. In comparison, would not this steel, because of its purity, rust much quicker than iron? The softer and purer steel or iron may be, the more susceptible to rust either becomes. It would therefore seem that to make them less susceptible, the particles of pure iron must be protected by some substance held in chemical combination, as is the graphitic carbon found in gray cast iron. The substance may be found in the metal itself, it may be taken up in the process of manufacture, or added as an alloy. It is well known that cast-iron pipe will last long in soil which would destroy wrought-iron or steel pipe in five years. Wrought pipe has been guttered and cut through by the condensate passing through it while the cast-iron fittings were scarcely marked.

Referring to a metallurgist's analysis, we find that the percentage of impurities in cast iron is from six to ten, in which carbon is as much as four and silicon as much as 2½ per cent. The value of carbon as a protective agent is well known. Sand and glass are forms of silica, and for our purpose would be considered rustless. The point to be deduced is that the ability of steel or iron pipe to resist destruction by corrosive agents is largely due to the impurities in the metal or to an alloy; that steel for making pipe can be alloyed to make it superior to iron, and no one need hesitate to use such steel pipe in preference to genuine wrought iron. While this is true, it is equally true that the general run of steel pipe is not made in this way.

Those who have machined both iron and steel know that good steel is easier to work, as it is more even in its structure and density. If, in addition to these qualities, we could be assured of a composition calculated to make it less oxidizible than iron, while retaining all the good qualities in respect to making a perfect weld and ease of working in the dies, all apprehension would be removed.

No account is taken, usually, of the composition of the steel or of the grade of the iron in pipe subject to tests for durability. Steels for various purposes are made to specifications, and why not for pipe? With this knowledge a comparative test would have some value; it would be better than the results of the comparisons of unknown compositions under conditions perhaps much different than those in other tests.

* *

Washed Air for Cooling Transformers

By Melvin Hall

SYNOPSIS—An argument pointing out the desirability of washing and cooling the air blast to transformers, as an aid to overload capacity, regulation, efficiency and durability in service.

*

The particular application of the air-blast transformer is in stations or substations of reasonably large capacity, where space is not too limited, or where water for the water-cooled type cannot be conveniently or cheaply obtained, and where the capacity of the ordinary oil-cooled type is not great enough. Its application is limited to those stations which do not demand voltages much in excess of 35,000 volts, and it is often used instead of the oil-cooled type to avoid increased risk from fire. The damper control is also advantageous.

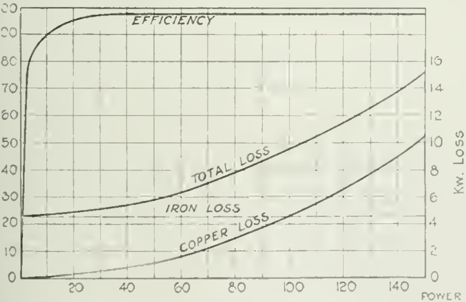


Fig. 1. Transformer Characteristics

Capacity for Overload

The actual output of a transformer is limited to a smaller value than the theoretical; first, because of the necessity of cool running; second, because the secondary electromotive force must be nearly constant, and third, because of the drop in efficiency at excessive outputs. The output of large transformers is directly limited by rise in temperature. Naturally, in the air-cooled type, this rise (other things being equal) is due to the air conditions, for if the heat is dissipated rapidly enough the temperature will be held normal.

The full-load rise for transformers is recommended to be not over 50 deg. C. (by resistance measurement) and 40 deg. C. by thermometer; and with an overload rating of 25 per cent. for two hours, an allowable increase of 15 deg. C. above that specified for full load. Increasing the output in the ratio of 6 to 5 increases both primary and secondary I^2R in the ratio of $36 \div 25 = 1.44$ times the normal copper loss. Also the resistance of copper changes rapidly with the temperature, so it is of prime importance to keep the temperature down.

When transformers are to be used with turbo-generators or other apparatus for which an overload capacity in excess of 25 per cent. is guaranteed, the transformer should have a corresponding overload capacity. This overload capacity from generators is made possible through use of the air washer; therefore it would seem reasonable that the transformers should be similarly equipped. The general curves of Fig. 1, plotted by W. Esty, illustrate a few transformer characteristics.

Durability

The life of a transformer depends primarily upon its ultimate temperature, since an excessive rise causes rapid deterioration in the insulation. The fact that apparatus which is kept clean will last longer than that which is periodically allowed to become dirty and then cleaned is never denied.

Regulation

Regulation by direct measurement is defined as the difference between no-load secondary voltage and full-load secondary voltage, divided by full-load secondary voltage, when a constant primary voltage is maintained. It has a decided bearing on the question of lamp life and uniformity of light.

The general formula used in practice for calculating the regulation with an inductive load is

$$per\ cent.\ regulation = p + \frac{q^2}{200}$$

where

p = Component of drop in phase with the terminal voltage;
q = Component in quadrature with the terminal voltage.

Its solution shows that regulation is largely a function of copper loss and should not be neglected. The copper loss being a function of resistance, it is easily seen that to improve the regulation requires that the transformer be kept cool.

SAFETY

The advantage of air-blast over oil-cooled transformers as regards safety has been referred to; a leak in a water-cooled transformer is equally disastrous. Breaking down of insulation is due either to overheating or to a high voltage discharge through damp insulation and foreign matter. The first of those causes will be discussed under "Heating."

If a high voltage is allowed to pass from the primary to the secondary or *vice versa*, thence into buildings, it endangers human life and makes loss of property by fire probable. The insulation is originally of good quality and able to exclude moisture; but the dirt from a dirty air supply clogs the ducts in the windings and decreases the dielectric strength to a great extent, especially if the intake air is wet. The best safeguard is to supply clean, cool air in sufficient quantity and without free moisture. The air-washer supplies this through the use of dense sprays and eliminator plates. The eliminators fulfill the function of preventing free moisture from getting into the apparatus.

HEATING

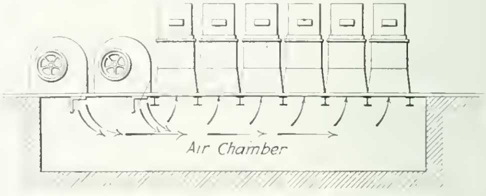
Vigilance is required in the problem of dissipating self-generated heat as rapidly as generated. This heat is proportional to the losses, which in turn are proportional to the cube of the linear dimensions. Since the ratio of radiating surface per kilowatt decreases rapidly with the increase in size, rise in temperature is the limiting feature in the economical manufacture of large transformers.

The best results with air-blast transformers can be attained only with a supply of cool, clean air, with provision for lowering the inlet air temperature in case of peak load or emergency. The effect of a soot, dust, vapor or water- and snow-laden air supply is well known. The foreign matter soon covers the radiating surfaces, rendering them inefficient as such, blocks the air passages and causes local or general abnormal heating; this will cause even the best insulation to deteriorate. An idea of the conditions may be had by noting the case of generators given by E. Knowlton:

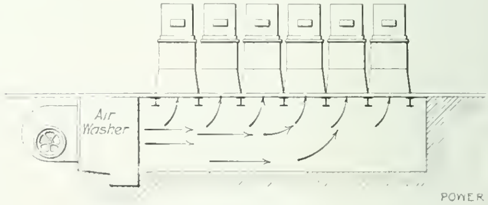
	Dirty	Clean
Machine Number 1, Rise in Temperture.	54	37
" " 2. " "	54	41

Guarantees usually prescribe that at normal load the temperature shall not exceed 40 or 35 deg. C. above the surrounding air. The discharge temperature of the air should not be more than 20 deg. C. above the temperature of the supply, and the General Electric Co. recommends a temperature of incoming air not greater than 25 deg. C. The amount of air should be about 150 cu.ft. per min. for each kilowatt loss, or 4 cu.ft. per min. per rated kilowatt at about 4 oz. pressure. In case of breakdown of a blower, it is unsafe to operate at more than half load, and even at that load for long.

Air washers are on the market that will guarantee to remove 98 per cent. of the foreign matter and cool the air from 2 to 32 deg. F., depending on the entrance temperature and relative humidity, by recirculating the water. On peak load, the air may be cooled down even more by using water direct from the mains. Thus the washer decreases the heating of the transformer directly by cooling the intake air and indirectly by preventing troubles due to a dirty air supply. Usually the air exhausts from the transformers directly into the station, in which case the air washer serves the additional purpose of purifying the station supply. Again, the advantage is manifest when one compares the statement in the last paragraph concerning fan breakdown with the following claims for the air washer: "When sprays are operating at 25 lb. pressure they will force the air through the washer against atmospheric pressure at a velocity of not less than 225 lin.ft. per min., by driving action of the sprays alone, independent of the fan."



Without Cooling and Washing



Transformers Supplied with Washed Air

FIG. 2. BANK OF TRANSFORMERS WITHOUT AND WITH AIR WASHING

Several manufacturers recommend that their transformers be cleaned at least once a month. Because of the bother, lack of implements and time, however, this is not always done. With the air washer this cleaning is not necessary. Also, some of the ducts which ordinarily become restricted are inaccessible for cleaning.

EFFICIENCY

Referring to the efficiency curve, Fig. 1, it will be noted that the core loss is constant. At full load the core loss equals the I^2R loss, and above this point the greatest loss is the I^2R, which increases rapidly. Although transformers are inherently highly efficient (from

95 to 98 per cent.), the raising to 98.5 per cent. would mean a saving of 50 kw. per hr. on a 10,000-kw. installation, which in the course of a year would amount to a large item. The increase in efficiency is easily found by the general methods for any particular station.

$$efficiency = \frac{output}{output + core\ loss + I^2R + power\ to\ drive\ auxiliary\ apparatus}$$

Cost of Operation

The cost of operating a set of air-blast transformers being known, the station manager would desire to know the additional cost of operation as well as the net saving due to the installation of the air washer. Since one of the guarantees which go with the washer is that the safe overload capacity of the transformer would be increased, it is natural that this advantage will be taken. If a transformer is to be operated on light loads the greater part of the day, it is much more economical to use one designed for a small iron loss than for a small full load copper loss. Under these conditions, the air washer running on peak load will keep down both of these operating expenses.

Since the rates and conditions are so widely different in different stations, no attempt will be made to figure the saving in an actual case; however, an outline of the points to be considered in the comparison of operating costs will be given:

Without Air Washer	With Air Washer
Core loss in per cent. of kw. rating (about 1%)	Slightly less
Copper loss in per cent. of kw. rating.	Less
Power to drive blower 1 to 5 per cent.	Plus power to drive pump minus power delivered by driving action of sprays
Price	Plus cost of air washer
Interest and depreciation	Same, plus that on cost of air washer
Cost of cleaning once per month	None

The writer believes that this proposition is worthy of careful investigation by those having facilities for making the necessary tests.

⁂

Transmitting Power by Compressed Air

By L. L. Brewster

SYNOPSIS—Efficiency of transmitting power through ir pipes, determining the flow of air and the friction luring transmission.

⁂

While much has been written about the transmission f power by flowing air under pressure through piping ystems, a great many are apt to confuse the transmission f air and the transmission of power and the formulas by hich both quantities are calculated. For instance, those nfamiliar with the subject are apt to err in assuming at the loss of power is proportional to the loss of pres- ire, as in the case of transmitting power through pip- ig by water.

It is quite correct to use the ordinary formulas for the ow of air through piping to calculate the amount of air ansmitted and its initial and final pressure, but these rmulas are not in themselves altogether sufficient for lculating the amount of energy or power of the air the beginning and end of the transmission system. ie more accurate measure of the efficiency of transmit- ig air through pipes is to credit the air with all of the ergy it can develop by isothermal expansion, both at e entrance to the pipe and at the exit; the efficiency transmission being the latter quantity divided by the rmer. The work done in the isothermal expansion of a en amount of air may be calculated from the equation

$$w = p_1 v_1 \log_e r$$

which

w = Work in foot-pounds;
p = Absolute initial pressure;
v = Volume of air at the beginning of compression;
r = Ratio of the absolute initial pressure to the absolute final pressure.

e potential amount of work which a given quantity of at the end of the transmission system could do by hermal expansion is represented by a similar formula, it is evident that while in both cases the air may be hermally expanded to atmospheric pressure, the initial sure before transmission must be higher than that at the end of transmission, so that the value of r will be different in each case. The mathematical expressions for the work done by isothermal expansion for the air at the end and the beginning of transmission respectively simplifies to the following expression when the former is divided by the latter, and this is, therefore, the equation for the efficiency; that is,

$$efficiency = \frac{\log_e r_2}{\log_e r_1}$$

r_2 being the ratio of expansion at the exit pressure and r_1 the ratio of expansion at the inlet pressure. Common logarithms may be used since the modulus cancels and the expression thus reduces to the form

$$E = \frac{\log r_2}{\log r_1}$$

The efficiency of transmission for several pressures is shown in Table 1. The figures at the head of the two sets of data indicate the initial absolute pressure (87 lb. and 145 lb. per sq.in. respectively), the absolute pressure to which the air is expanded in all cases (14.5 lb. per sq.in.), the initial ratios of expansion (6 and 10) and the logarithms of these ratios (0.7781 and 1). It is evident from the table that when the absolute pressure at the end of the transmission system is as shown by the figures at the top of the several columns, the ratios of expansion and the efficiencies are indicated by the figures directly under.

TABLE 1 EFFICIENCY OF TRANSMISSION

$p_a = 14.5$ $p_1 = 87$ $r_1 = 6$ $\log r_1 = 0.7781$

p_2....	85	80	75	70	65	60
r_2.	5.86	5.52	5.17	4.83	4.48	4.14
$\log r_2$.....	0.7679	0.7419	0.7135	0.6839	0.6513	0.6170
E........	0.987	0.953	0.917	0.879	0.837	0.793

$p_a = 14.5$ $p_1 = 145$ $r_1 = 10$ $\log r_1 = 1.$

p_2.	140	135	130	125	120
r_2.	9.66	9.31	8.97	8.62	8.28
$\log r_2$...............	0.9850	0.9689	0.9528	0.9355	0.9185
E..........	0.98	0.97	0.95	0.93	0.92

From the table it would appear advantageous to transmit air at as high pressure as possible. The work cannot be fully recovered without expanding down to atmospheric pressure, and this is usually impractical unless the air is reheated, because the temperature of the air expanded to atmospheric pressure is usually so low that frost is formed around the discharge valves and passages and finally chokes the passage.

When the transmitted air is used without expansion, the efficiency of transmission is represented by the formula

$$E = \frac{r_1 (r_2 - 1)}{r_2 (r_1 - 1)}$$

Flow of Air through Pipes

The formulas which are derived purely from the mathematical considerations of the flow of air do not seem to agree with experimental results so well as do some of the empirical formulas derived principally from the results of carefully conducted tests. The problem most frequently encountered in the flow of air is that of finding the amount in cubic feet which will flow through a given size pipe in a given time under given conditions of temperature and pressure. The amount of air flowing from the receiver or tank under pressure into the atmosphere is sometimes desired, and such flow is governed by Napier's law, by which the calculated flow is approximately the same when the discharge is into any pressure less than 60 per cent. of the initial pressure.

For the amount of air flowing in power-transmission systems, the formulas of Prof. E. G. Harris are widely used for calculating the flow in small pipes, and those of W. H. Hammon for calculating that in larger pipes. For 11-in. pipes the formulas of Harris or Hammon give about the same results. For smaller-size pipes the Harris formula gives somewhat greater values for the loss of pressure and for larger pipes the Hammon formula gives slightly greater pressure drops. Hammon's formula for the loss of pressure, due to friction, is as follows:

$$P_1^2 - P_2^2 = 0.0004555 \frac{V^2 L}{d^5}$$

in which

P_1 = Absolute initial pressure;
P_2 = Absolute discharge pressure;
d = Interior diameter of pipe in inches;
L = Length of pipe in feet;
V = Volume of air per minute in equivalent cubic feet at atmospheric pressure (volume of free air per minute).

To facilitate the use of this formula, Table 2 gives values of d^5 for the standard-size pipes.

TABLE 2

Nominal Dia. of Pipe, In.	Exact Interior Dia., d, In.	d^5
1	1.048	1 266
1¼	1.380	5 000
1½	1 610	10.800
2	2.067	37.7
2½	2 468	91.5
3	3 067	271
3½	3 548	561
4	4.026	1,054
4½	4 508	1,860
5	5 045	3,270
6	6 065	8,150
7	7 023	17,100
8	7 981	32,500
9	8 937	57,000
10	10 018	100,500
12	12 000	248,000
14	14 000	538,000

The loss of pressure by friction for compressed air can, according to the tests of Professor Harris, be expressed as follows:

$$P_1 - P_2 = (0.31 - 0.00768\, d) \frac{V^2 L}{1000\, P_3 d^5}$$

or for L = 1000 ft.

$$P_1 - P_2 = (0.31 - 0.00768\, d) \frac{V^2}{P_3 d^5}$$

The loss by friction in transmitting air can be calculated by either of the two formulas given, but such calculations are greatly simplified by the use of Table 3, which appears in the book on "Compressed Air," by Professor Harris. The directions for using the table are given at the top.

TABLE 3. FRICTION IN AIR PIPES

Divide the number corresponding to the diameter and volume by the ratio of compression. The result is the loss in lb. per sq.in. in 1000 ft. of pipe

Dia. of Pipe, In.

Cu Ft. of Free Air per Min.	½	¾	1	1¼	1½	1¾	2	2½	3
6	27.3	3.54	0.83	0 26					
12	108.3	14.26	3.32	1.05					
24		56.64	13 28	4.20	1 71	0.78			
36		126 4	29.86	9 45	3.84	1.75			
48		226.6	53.15	16.80	6 83	3.12	1.60		
60			84.94	26 26	10.70	4.87	2.50		
72			119.8	37.90	15.40	7 03	3.62	1.17	
84			163 7	51.46	20.90	9 55	4.91	1.59	
96				67.21	27.30	12 48	6.41	2.07	
108				85.06	34.55	15 80	8.12	2.62	
120				105.0	42.67	19.50	10.00	3.25	
150				164 1	66.53	30.47	15.66	5.06	1.85
180					96 00	43.87	22.54	7.28	2.67
210					130 7	59 71	30.70	9.91	3.63

Cu Ft. of Free Air per Min.	1¾	2	2½	3	3½	4	4½	5	6
240	78.00	40 09	12.94	4.74	2 13				
270	98.70	50.72	16.48	6.00	2.70				
300	121.8	62.62	20.23	7 41	3.33				
330		75.78	24.57	8.97	4.03				
360		90.29	29.12	10 67	4.80				
390		105.5	34.20	12 53	5.63				
420		122.8	39.64	14.52	6.53	2.87			
450			45 50	16.67	7.49	3.30			
480			51.88	18.97	8.53	3.75			
510			58.44	21.42	9.62	4.23			
540			65.39	24.01	10.79	4.75			
570			73 00	26 75	12.02	5.29	2.94		
600			80 90	29 64	13.32	5 86	3.25		
660			97.90	.35.87	16.12	7.09	3.93		
720			116.50	42.68	19 19	8 43	4.68		
780				50.10	22.50	9.00	5.50	3.25	
840				58.10	26.11	11.48	6.37	3.76	
900				66.70	29 98	13 18	7.32	4.32	
960				75.88	34.10	15.00	8.32	4.92	
1020				85.65	38 50	16.93	9.40	5.55	2.23
1080				96.04	43.17	18.98	10.53	6.22	2.50
1140				107 00	48.10	21.15	11.74	6.93	2.79
1200					53.29	23.44	13.01	7.68	3.09
1320					64 49	28.36	15.74	9.29	3.73
1440					76.74	33.75	18 73	11.06	4.44
1560					90 05	39 61	21.89	12.98	5.22
1680					104 45	45.95	25.50	16.78	6.05

Cu Ft. of Free Air per Min.	4	4½	5	6	8	10	12
1800	52.73	28.23	17 82	6.95	1 65		
1920	60.00	33.30	19 66	7 90	1 87		
2040	67.74	37.59	22 20	8.92	2.12		
2160	75.94	42.15	24 89	10 00	2 37		
2280	84.60	46.95	27 65	11.14	2.64		
2400	93.74	52.02	30.72	12.35	2.93	0.96	
2520		53.38	33.87	13 61	3.23	1.06	
2640		62 96	37 17	14.94	3.55	1.16	
2780		68.81	40.66	16.33	3.88	1.27	
2880		74 92	44.78	17.78	4.22	1.38	
3000		81.30	48 00	19.29	4 58	1.50	
3300		98.37	58.08	23.34	5.54	1.81	
3600			69.13	27.78	6.59	2.16	0.87
3900			81.13	32.60	7 74	2.53	1.02
4200			94.09	37 81	8.97	2.94	1.18
4500				43 41	10.30	3.37	1.36
4800				49 39	11.72	3.84	1.54
5100				55 76	13.23	4.34	1.74
5400				62 51	14 83	4 86	1.95
5700				69 62	16.53	5.41	2.18
6000				77.18	18.31	6.00	2.41
6600					22.16	7 26	2.92
7200					26.37	8.64	3.47
7800					30.95	10.10	4.07
8400					35.90	11.76	4.73
9000					41 20	13.50	5.40
9600					46.88	15.36	6.17
10200					52.92	17.34	6 97
10800					59.36	19.44	7.81
11400					66 11	21.66	8.70
12000					73.25	24.00	9 64
13200						29.04	11.67
14400						34 56	13.89
15600						40.56	16.30
16800						47 40	18.90
18000						54.00	21 70
19200						61.43	24 70
20400						69.36	27.87
21000						77.75	31.25
22800						86.64	34.82
24000						96.00	38.58

For example, suppose it were desired to transmit 60 cu.ft. of air per minute through a 4-in. pipe, the initia pressure being 73.5 lb. abs., so that the ratio of com pression above atmosphere is 73.5 divided by 14.7 or 5. Thus, according to Table 3, the figure corresponding to 600 cu.ft. and 4 in. diameter—that is, 5.86—is to be divided by the ratio of compression 5, and the quotient, 1.172, will be the loss of pressure in pounds per square inch in 1000 ft. of pipe. The loss in pressure due to friction for any length of pipe other than 1000 ft. is proportional to the length, so that the figures obtained from the table may be multiplied by the length in feet and divided by 1000 for ascertaining the actual loss in any given length of pipe. Subtracting this loss of head in pounds per square inch from the initial pressure in pounds per square inch will give the absolute delivery pressure in pounds per square inch.

TABLE 4. NUMBER OF SMALLER PIPES TO EQUAL CARRYING CAPACITY OF LARGER PIPE

	Diameter of Pipe, In.														
Dia., In.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1														
3	15.6	2.8	1													
4	32.0	5.7	2.1	1												
5	55.9	9.9	3.6	1.7	1											
6	88.2	15.6	5.7	2.8	1.6	1										
7	130	22.9	8.3	4.1	2.3	1.5	1									
8	181	32	11.7	5.7	3.2	2.1	1.4	1								
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1							
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1						
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3						
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1					
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2					
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1				
15	871	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2				
16		181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1			
17		211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2			
18		243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1		
19		278	101	49.1	28.1	17.8	12.1	8.7	6.5	5	3.2	2.1	1.5	1.1		
20		316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	
22		401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	
24		499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26		609	221	108	61.7	39.1	26.6	19.0	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28		733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3	2.3	1.5
30		871	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36			499	243	130	88.2	60	43	32	24.6	15.6	10.6	7.6	5.7	4.3	2.8
42			733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4.1
48				499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5.7
54				670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60				871	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

It is sometimes desirable to know the number of pipes of a given size which are equal in carrying capacity to one pipe of a larger size. It has been found sufficiently accurate for practical purposes to assume that where the head is the same, the volume delivered varies about as the square root of the fifth power—that is, as the 2.5 power. Table 4 has been calculated on this basis. The figures opposite the intersection of any two sizes is the number of the smaller-size pipes required to equal the carrying capacity of the larger-size pipe. Thus, one 8-in. pipe will deliver the same quantity of air under the same conditions as 1.4 seven-inch pipes; 2.1 six-inch pipes; 5.7 four-inch pipes; 11.7 three-inch pipes; 32 two-inch pipes, etc.

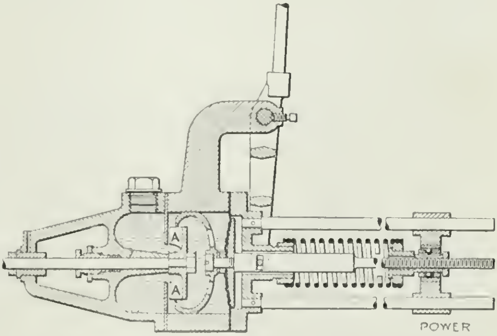
The common problems connected with the transmission of power by compressed air should be easily solved by the use of the formulas and tables given herewith, and while extreme accuracy is impossible, it is the opinion of the best authorities that the result obtained will more nearly agree with actual practice than would be the case if many of the other formulas and tables were used. For the solution of the more complex problems involving the reheating of air, the reader should consult the textbooks of some standard authority.

*

Centrifugal Pressure Governor for Steam Turbines

We have previously referred to a governor built by the Sulzer Bros. of Switzerland, which consisted of a small centrifugal pump or impeller, driven by the turbine itself. The faster this pump was driven the greater the pressure which it generated, and this pressure, balanced by a spring-loaded piston or diaphragm, was made to control the inlet mechanism.

L. C. Loewenstein, of Lynn, has recently taken out, and assigned to the General Electric Co., a patent for the device shown in the accompanying engraving. *AA* is the impeller which receives oil at its center and delivers it at its circumference under a pressure dependent upon the peripheral speed. The delivery port is partly covered by a bowl-shaped piece, the knife-edge rim of which is at the extreme left, inclosing the entire propeller when the throttle is entirely open. As the pressure increases, and the diaphragm is pushed back, the bowl-shaped piece is retired with it, cutting off more and more of the fluid delivered by the impeller from acting upon the diaphragm. An increase in speed, therefore, not only increases the pressure which acts on the diaphragm, but forces the bowl-shaped regulator in the same direction and at once decreases the quantity of oil delivered against the diaphragm, which relieves the pressure and prevents the diaphragm from compressing the spring to excess. This overcomes any tendency of the governor to hunt and renders it more sensitive and accurate in operation, the governing being limited to only a short range of deflection of the diaphragm.



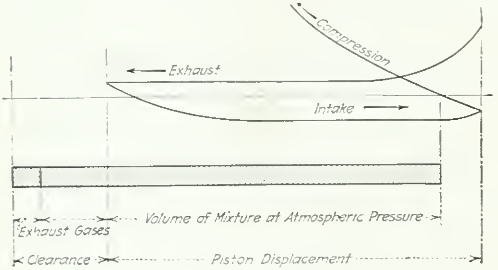
Centrifugal Governor for Steam Turbine

Increasing Output of Gas Engines

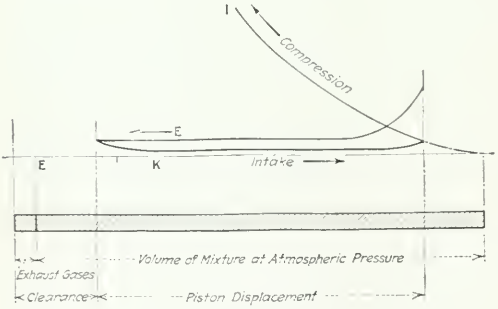
SYNOPSIS—Description of a method employed by Ehrhardt & Sehmer for increasing the output of their engines. The burnt gases are first scavenged and the working charge then admitted under pressure, thus increasing the weight of the charge and consequently raising the mean effective pressure.

*

The output of a gas engine (other things being equal) is dependent on the temperature and pressure of the working charge taken into the cylinder. In two-stroke-cycle engines, the good influence through a reduction in temperature by scavenging the burnt gas with cold air is well known. It is obvious that in four-stroke-cycle engines a similar advantage can be gained by scavenging. Lowering the inlet gas temperature by this means makes possible an increased weight of charge and also fills the compression space with working material instead of partly with burnt gases; see Fig. 1. Furthermore, through the scavenging of the waste gases, the burning power of the mixture is increased and a sharper ignition is obtained.



WITHOUT SCAVENGING



WITH SCAVENGING

Power

Fig. 1. Stop Diagrams Illustrating Greater Charge with Scavenging

Four-stroke-cycle engines with scavenging of this nature have been on the market for several years in England, and in Germany a similar method has been tried on large engines. Further steps have been taken by Messrs. Ehrhardt & Sehmer, of Saarbrucken, Germany, by combining the scavenging process with increased pressure of the charge, and the results up to the present indicate a wide field of application, as it appears that the economy is raised as well as the output increased and the working conditions improved.

In this new method the charge is placed under a pressure of 10 to 15 lb., and a steady flow is attained by passing both the gas and air through a turbo-blower. Before the exhaust stroke is finished, and just before the exhaust valves are closed, the inlet valve for the air under pressure opens and the compression space is scavenged free from burnt gases. When the piston passes dead center, the exhaust valve closes, the inlet valve opens wider, and at the same time the gas valve also opens; thus both air and gas under pressure flow together into the cylinder. The mixture is compressed up to from 90 to 120 lb. and ignition takes place in the usual manner.

The increased output which results is due essentially to the increased weight of charge brought about by the economical use of the compression spaces by introducing the mixture under pressure. The blowers which supply the air and gas under pressure are driven either by electric motors or steam turbines, the power consumption being from 6 to 7 per cent. of the engine output. Against this power consumption must be reckoned the work of suction of the normal four-stroke-cycle engine, while due regard must be paid to the largely increased output.

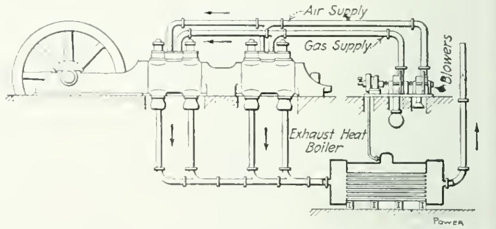


Fig. 2. Arrangement Whereby Blowers Are Driven by Turbine Supplied from Exhaust-Heat Boiler

With one arrangement the blowers are driven by steam turbines, the steam being raised in boilers heated by the exhaust gases, of the engine, as shown in Fig. 2. In this way the whole of the increased output is available for useful work without reduction.

An interesting feature of the curves shown in Fig. 3 is the almost constant value of the heat consumption between full load and about 70 per cent. full in the high-output engines, whereas in the ordinary four-stroke-cycle engines, the corresponding curve rises rapidly between these limits, showing an advantage in respect to heat consumption for the high-output method of working in stations having loads varying between three-quarters and full load.

This method involves no extra valve-gear, as will be seen by referring to Fig. 4. It is distinguished from the normal valve-gear only through the formation of the cams on the layshaft and the form of the disk valve for the closing of the gas supply. The disk valve on the inlet spindle has, compared with the normal disk valve, a greater lap. Since the inlet and disk valves move together, the inlet valve for scavenging must open earlier than in the normal method, hence the lap must be made so large that the air valve opens earlier than the gas valve. The remainder of the valve-gear and the general construction of the engine remain unaltered.

At the Skinningrove Iron Co., Ltd., of Carlin, England, there is a plant consisting of two $25\frac{11}{32}$x$32\frac{11}{16}$-in. gas engines running at 136 r.p.m., together with three larger units having $37\frac{13}{32}$-in. cylinders by $43\frac{5}{16}$-in. stroke and running at 109 r.p.m. These engines operate on blast-furnace gas and drive 3-phase generators. Tests on one of the larger engines showed the following results:

	Normal Working	High Output Method
Normal continuous output, b.hp........	1300	1880
Mean piston pressure, pounds per sq.in..	60	77.5
Maximum momentary output, b.hp......	1460	2055
Mean piston pressure, pounds per sq.in..	67.5	84.5

This maximum load by no means represents the possible upper limit, as it would be possible to operate the engine at a mean pressure of 95 lb. per sq.in. Before the scavenging plant was put into operation, it was necessary for two engines of 800 hp. and two of 1400 hp. to run in parallel. Since the high-output method has been adopted, it has been found possible for the two 1400-hp. engines alone to deal with the load requirements, so that the smaller engines stand as spares.

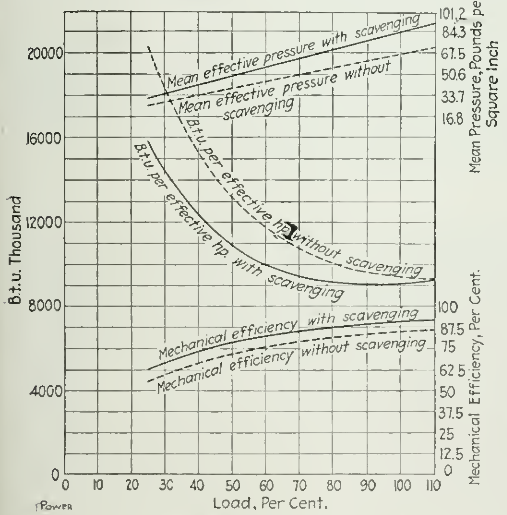


FIG. 3. HEAT CONSUMPTION, EFFICIENCY AND PRESSURE CURVES

In the central station of the Rochling'schen Eisen und Stahlwerke at Voelkingen there are installed two gas engines having 45¼-in. cylinders by $51\frac{3}{16}$-in. stroke and running at 94 r.p.m. They operate on the Ehrhardt & Sehmer system with blast-furnace gas and drive direct-current generators. The following shows some of the results obtained:

	Normal Working	High Output Method
Mean load, kilowatts..................	1,318	1,830
Maximum load, kilowatts..............	1,570	2,140
Mean energy production in 12 hours, kilowatt-hours	14,300	19,950
Maximum energy in 12 hours, kilowatt-hours	15,270	20,940

The large overload capacity of this type of gas engine makes it adaptable to rolling-mill work inasmuch as such engines must operate with strongly fluctuating loads. An advantage is found also with this new method in power houses located at a considerable height above sea level. It is known that with gas engines operating under such conditions, the loss in output is about 1 per cent. for every 300 ft. above sea level. Such loss, however, can by the high-output method be diminished by correspondingly varying the gas and air blowers.

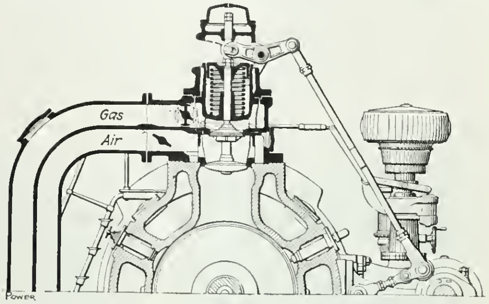


FIG. 4. VALVE-GEAR OF EHRHARDT & SEHMER ENGINE

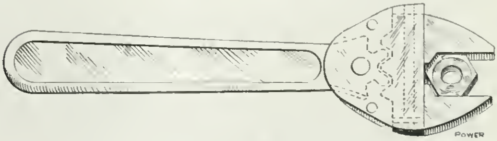
The manufacturers are said to be building engines of this description in sizes up to 5500-kw. capacity.

⁂

Cochran Speednut Wrench

A wrench that has no thumb-screw adjustment, and is capable of gripping a nut from ¼ to ¾ in. in size is illustrated herewith.

It has only three parts. One jaw is fixed and is a part of the head in which the other jaw slides. The sliding jaw has a rack which engages with teeth formed at the end of the pivoted wrench handle, so that the harder the pull, the tighter the grip.



SPEEDNUT WRENCH

The wrench is made by the Cochran Pipe Wrench Manufacturing Co., 7800 Woodlawn Ave., Chicago, Ill.

⁂

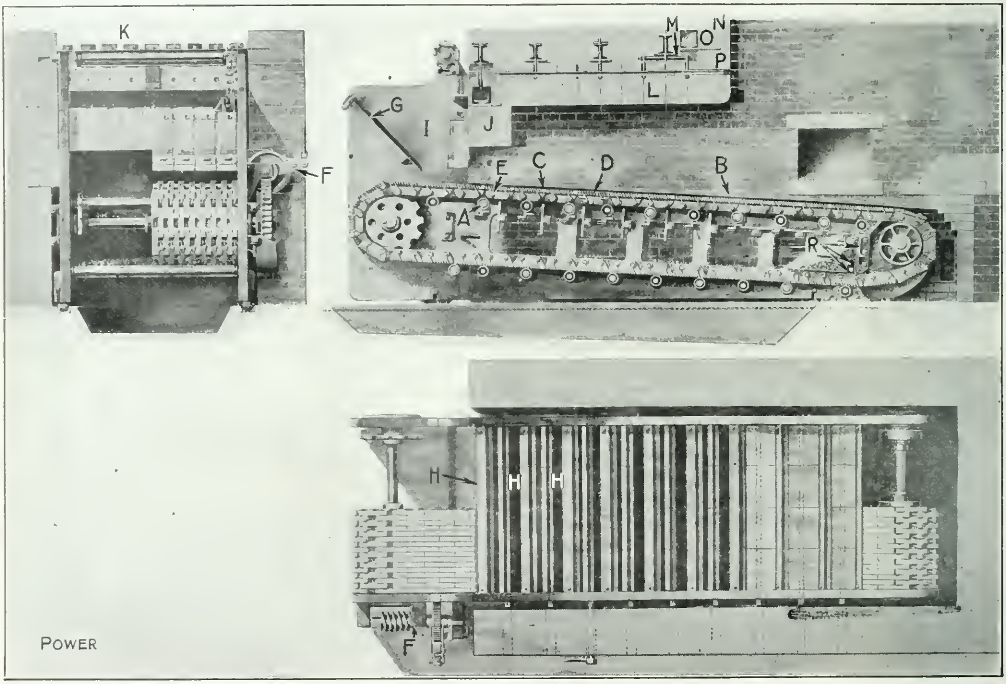
Water in Exchange for Refuse—Milwaukee has a refuse incinerator with a total capacity of 300 tons a day. A 6000-kw.-hr. turbo-generator is driven by the steam raised in a 200-hp. boiler. The current from the generator is to be transmitted to a flushing-tunnel pumping station, some two miles distant, which will pump lake water into the north end of the Milwaukee River for flushing and cleaning purposes.

⁂

Texas Coal Production in 1913—The state of Texas mined 2,429,144 short tons of coal in 1913, valued at $4,288,920, according to E. W. Parker, of the United States Geological Survey. This production was nearly evenly divided between lignite and bituminous coal, with the balance slightly in favor of the latter. Both classes of coal showed increases in production in 1913, and both made their record output. The total production in 1913 exceeded that of 1912 by 240,532 short tons, or 11 per cent., in quantity, and by $633,176, or 17 per cent., in value.

Illinois Chain-Grate Stoker

In the new model of the Illinois chain-grate stoker, the side frames are connected and held at right angles to the drive shaft by front and rear cross-braces. The side frames are at right angles to the drive shaft and the carrying rollers *A*. Every second carrier is a tight roller, consisting of a pipe spreader, about which the roller revolves. The side frames are tightly drawn against these spreaders by rod bolts; in addition, diagonal braces provide means of squaring the frames. The frame is mounted on wheels and forms a self-contained unit which can be moved on rails in or out of the setting at will.



Details of the Illinois Chain-Grate Stoker

The frame tops are protected by brickwork built up on ledge plates *B*, set flush with the line of the moving chain.

The links *C* of this chain are 9 in. long. The air slots on the opposite sides of the links, sloping in opposite directions, offer resistance to fine coal sifting through the grate without reducing the available air space, which in the standard links is 23 per cent.

Should a link in any way become broken, the grate can be repaired without delay by inserting a repair link *D*, made in two parts and having open rod holes. The halves are then slipped into place, a pin is driven through a hole cored in the head of the link, its ends are peaned into a slight depression, and the damage is repaired.

The chain rods *E* are round, with the advantage that they can turn, thus bringing all parts of the surface to wear, and there is no danger of the links becoming locked in a humped position.

The chain is driven by sprockets keyed to a front shaft. On the rear shaft are idler drums, kept in place by set collars. Motion is imparted to the grate by means of the driving mechanism *F*. This drive consists of a ratchet and pawl and a worm and wormwheel, by which combination the grate can be run at five speeds. The principal advantage of the worm and wormwheel is that any slack in the chain can be taken up by means of bolts at the front of the stoker while it is in operation.

The coal feed can be regulated by changing the driving speed and by raising or lowering the tile-lined feed gate. There are no bolts in the entire feed-gate frame to rust from coal moisture. When placing the tile it is only necessary to slip the clip on the end of the tile, hook the shoe *I* on the clip, and hang the tile, by means of the shoe, on the feed-gate frame. The shoe and tile are then secured by a small tapered pin. All parts are accessible by merely dropping the hopper plate *G*, which is held in place by a hook.

The ash baffles *R*, between the two strands of chain at the rear of the stoker, have been devised to prevent any air leakage at places where excess air would be detrimental. The air is distributed to various parts of the grate by movable dampers *H*.

When the stoker is doing half duty, enough dampers are closed to make the active grate surface just large enough to carry the load with the most economical rate of combustion. Since efficiency is proportional to furnace temperature, a short hot fire, with no excess of air, is more efficient than a dead, smoldering fire carried to the end of the grate through cutting the stack draft and decreasing the rate of combustion per square foot of grate to an unprofitable figure. By opening or closing the dampers, the stoker is adaptable to all conditions from a banked fire to above 200 per cent. rating.

The design of arch affords a large combustion chamber of practically uniform cross-section its entire length. The short front arch makes it impossible for the coal to enter the furnace for a foot or more before igniting. The arch, being high at the front of the setting, allows the flame to propagate itself freely, thus raising the temperature of the short ignition arch, and also reflecting the heat where it is required for raising the temperature of the coal to its point of ignition as soon as possible after entering the furnace.

The supporting channels rest on plates in the side walls. Between the front channels, hangers are inserted to support the channels carrying the cast-iron arch brackets, which support the tile *J* by fitting into grooves in the side of the tile. This is shown on the front view of the stoker setting. Between the channels, hanger plates having holes punched in them, for receiving the pin *K* on one end, and the pipe *L* on the other end, are inserted. The rod *M* is used to avoid excessive overhang on the end portion of the pipe *L*. This construction permits of a substantial curtain wall *N*, supported by channels. Between the flanges of the channels are inserted small ⊥ section clips. Beneath the channel and resting on the cross bars of two adjacent ⊥ clips are the plates *O*. This arrangement gives a light, durable support, and permits those parts subjected to the heat to be replaced at small cost.

The firebrick-arch blocks, having holes through them, are threaded on the pipe *L*, hangers being placed at intervals not exceeding two feet. The holes in the tile are so far from the surface that all possibility of the blocks breaking, due to perforating, is obviated. Any width of arch is made up by placing the required number of these independently suspended sections side by side.

As the rear tile is generally subjected to the most severe usage, provision has been made for renewing this block. The cast-iron plug *P* is inserted in the ends of the pipe, and in the event that the tile and supporting plug are burned off, all that is necessary to replace this end member is to remove the old tile and plug and put new ones in their places. This often saves the expense of a whole new arch. The plug *P* has a hole through the center which permits a small amount of air to be drawn into the furnace and keeps the suspension cool. Since the air is preheated in passing through the tile it is a benefit rather than a detriment to high furnace efficiency.

To enable the fireman to watch the furnace condition closely, inspection doors are provided and, with the above mentioned means of regulation at his command, he can closely approximate ideal conditions.

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Will Quizz, Jr.

SYNOPSIS—Quizz is disgusted with a mechanical engineers' handbook because the pulleys he figured by its rule did not give the right speed to the pump. Chief Teller gives him a word about "horse sense."

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"There, ding it! Chief, I did it by the rule, and it's wrong."

"Oh, now don't get all het up, Will; there's a limit to the application of almost every rule. You have to know something—even if it be only hoss sense—in order to use handbooks."

"Yes, but a rule is a rule, and this one is a simple 2 × 2 = 4 tabloid. I wanted to belt that old pump to the blower shaft. It takes 84 r.p.m. of the pump to give the water we need, and the blower makes 150; what should be the diameters of the pulleys?"

"What does the rule say, Will?"

"Why, 'multiply the diameter of the driven pulley by its speed, and divide by the speed of the driver.' I got a 25-in. pulley with a 6-in. face from the storage room and put it on the pump. Then I used the rule to calculate the size of the pulley for the blower shaft. Thus,

$$\frac{25 \times 84}{150} = 14 \textit{ inches}"$$

"What speed do you get?"

"Just about 80. The pump doesn't keep up to 84. I'll throw that handbook into the furnace."

"It'll make more B.t.u. by burning it in your mental dutch oven. There are two reasons for the pump losing four revolutions. You did not allow for the slip of the belt. Also, if you are as particular as the merchant who bought one million pins and complained to the wholesaler that there were three pins short, then take into account the thickness of the belt."

"The book does not say anything about the slip or thickness of the belt, and I don't know how to figure it. Show me, Chief."

"Your test shows the slip to be about 5 per cent. of the pump speed. Just figure for about that much extra and use a 14¾-in. pulley and you'll get 84 r.p.m. and better. The figuring would be like this:

$$84 \div (100 - 0.05) = 88.4$$

and

$$\frac{88.4 \times 25}{150} = 14.73$$

or a 14¾-in. pulley for the driver. A pump, like a watch, is better a little fast than slow. The thickness of the belt does not affect the relative rotative speed when both pulleys are of the same diameter, but the greater the difference in their diameters the more influence it will have. The rule is, 'add to the diameter of each pulley one thickness of the belt,' and proceed as shown. Try a few calculations, Will, using extremes in belt thickness and pulley ratios."

Engineering Phases of the Pittsburgh Smoke Problem

SYNOPSIS—A digest of the Mellon Institute's latest report with comments.

It is interesting to read the latest report of the Mellon Institute of Industrial Research and School of Specific Industries on the Engineering Phases of Pittsburgh's Smoke Problem. It clearly shows that, outside of the topography favorable to the smoke nuisance, Pittsburgh's smoke difficulty is due chiefly to carelessness in the operation of boiler furnaces.

PITTSBURGH CENTER OF GREATEST COAL FIELD

Pitsburgh is the center of one of the greatest soft-coal fields in the world; this coal is highly volatile and, unfortunately from the viewpoint of smoke abatement, is cheap. Added to this is the fact that the industries of the city make the plants large users of coal. The figures of Mr. Searle, chief smoke inspector for the city, show that in 1912 the Pittsburgh district consumed 17,-721,783 tons, making it the largest consumer of bituminous coal in the world. In addition, it uses five million tons of coke, but coke, however, is not a smoke producer. With such an enormous consumption and with the price of fuel so low, the natural tendency is to hire cheap labor in the boiler room and ignore the use of equipment conducive to economical and practically smokeless combustion.

TABLE IX. SUMMARY OF PLANT SURVEY WITH SMOKE RECORDS

Fired by	Number of Plants	Fuel	Thickness of Fire	Number of Boilers per Plant	Boiler Hp. per Plant	Type of Boiler	Nature of Load (1)		Number of Stacks	Smoke Records		
							Uniform	Variable		Per Cent. of Black Smoke	Smoke Equal to or Greater Than 60% Black (2) Min.	Stack Clean Min
Hand	56	54 P'gh coal 1 Low volatile	3" to 24"	1 to 10	20 to	*32 Horizontal return tubular			51	Average per hr. 23.4 Maximum 66.0 Minimum 0.3	Average per hr. 12 2 Maximum 40.8 Minimum 0 0	29.8 52.8 0.0
		1 Wood			2500	†18 Water tube, 3 locomotive, 3 two flue	30		11	Average per hr. 13 6 Maximum 25 0 Minimum 4 8	Average per hr. 5.2 Maximum 13.5 Minimum 1.0	34.5 48.5 18.8
Chain-grate stoker	33	33 P'gh coal slack or nut and slack in 23 plants, run of mine in 10	4" to 8"	1 to 26	250 to 6500	All water tube 23 horizontal type 10 vertical type.	8		36	Average per hr. 10.5 Maximum 51 0 Minimum 0.0	Average per hr. 2.1 Maximum 27.0 Minimum 0 0	37.6 60.0 0.0
Front feed avalanche type of stoker	34	33 P'gh coal slack, nut and slack, or run of mine and slack in 21 plants, crushed run of mine or nut size in 13	3" to 24"	2 to 22	450 to 7980	All water tube horizontal type in most cases	8	26	60	Average per hr. 27 2 Maximum 63.0 Minimum 1.1	Average per hr. 14.6 Maximum 57.5 Minimum 0.0	22.8 57.0 0.0
Side-feed stoker	19	P'gh coal in 13 plants Youghiogheny in 1 plant. Slack or nut and slack size fuel used in 13 plants. Run of mine in 1 plant.	2½" to 12"	1 to 20	150 to 10,000	3 Horizontal return tubular 15 water tube, 1 fire tube	4	10	21	Average per hr. 7 6 Maximum 29.0 Minimum 1	Average per hr. 1.9 Maximum 9 0 Minimum 0.0	43.8 60.0 10.75
Under-feed stoker	10	P'gh coal in 9 plants. New York and Cleveland. Gas coal in 1 plant. Slack or nut and slack used in 9 plants and run of mine in 1 plant.	4" to 30"	1 to 12	85 to 1200	4 Horizontal return tubular 5 water tube 1 Scotch marine	4	6	12	Average per hr. 6 5 Maximum 15.0 Minimum 0.0	Average per hr. 1.35 Maximum 13.0 Minimum 0.0	43.1 59.8 10.8

Remarks:—*These stacks are connected to boilers without fire tile roofs or coking arches over the fire. †Boilers are equipped with Dutch ovens and with coking arches greater than 2'6" in length over the fire. 1. In a number of cases information on the nature of the load was not obtained. 2. An average of eight minutes per hour of smoke equal to or greater than 60% black constitutes a violation of the city smoke ordinance.

ENORMOUS SOOT FALL

Careful tests to determine the amount of soot fall in the district bring out the fact—not to be wondered at when the consumption is considered—that it is very much greater than for cities like London, Leeds and Glasgow, the annual fall being 1031 tons per square mile to 539 for Leeds, 426 for London and 820 for Glasgow.

The district is on the point of land where the Allegheny and Monongahela rivers join the Ohio. With hills on nearly all sides, with fogs and north and northwest winds to drive the smoke into the business and residential sections, there is every natural barrier to prevent the diffusion of the smoke after it gets into the atmosphere.

POOR FURNACE CONDITIONS IN BUSINESS SECTION

In no part of the city is smoke a greater nuisance than in the business section and its immediate vicinity; and unfortunately that district produces, according to the report, nearly all of the smoke in that section.

The reasons are that the boiler rooms of the office, store and public buildings are usually cramped and crowded, having furnaces of inadequate volumes, tortuous flues and stacks and are dark and illy ventilated, thus offering inducements to negligence by the firemen. Investigators of the smoke problems of cities know that while Pittsburgh is not alone in this, the extreme conditions surely offer a convincing reason for the necessity of compulsory engineering supervision of plans and specifications for new and remodeled furnaces and flues. These preventable conditions are also true of the manufacturing territory, which produces most of the smoke made in the district. Of the stationary plants investigated, it was shown that at least a 30 per cent. decrease in fuel consumption could be effected by changes in furnace construction and firing methods.

What a field for the combustion engineer if the price of fuel were high or the plant owners should suddenly be filled with enough civic pride to provoke enthusiasm in combating the smoke evil!

The Merits of Firing Methods

In discussing hand firing, the report contends that neither the alternate nor coking methods can be made to produce as good results with a vertically as with a horizontally baffled water-tube boiler, because with the former the gases from the green coal immediately rise from the fire into the cooler volume above, while with the horizontal baffling, these gases must pass between the incandescent part of the fuel bed and the refractory fire tile on the bottom row of tubes.

The Chicago Method Good

As only the spreading, alternate and coking methods are discussed, one concludes that a combination of the spreading and coking method, so favorable in hand-fired plants in Chicago, was not tried.

Illinois coal, generally used in Chicago, is higher in volatile matter than Pittsburgh coal and the method of firing as recommended by Mr. Monnett, chief smoke inspector for Chicago, should be productive of as good results in Pittsburgh as in Chicago. The method is to charge the furnace by throwing coal in small piles distributed over the fuel bed. When the volatile has been driven off the piles are leveled.

This is a compromise between all three methods, spreading, alternate and coking, that will, to an appreciable extent, overcome the disadvantages of each of these methods. It is conceded that the spreading method is invariably bad; distillation is so rapid with the alternate method that more or less dense smoke is produced for short intervals after each firing; with the coking method, distillation is slow while the coal is in a pile at the front of the grate, but, when pushed back on the incandescent fuel, is so rapid as to make black smoke, the amount depending upon the quantity of coal pushed back and on its volatile content. With what may be called the Chicago method, the coal to be coked is in small piles on the incandescent bed instead of in one large pile on the front of the grate. Distillation is complete and slow enough from the piles so that while coking and when spread over the grate, a large volume of black smoke is not produced. Like other methods, this entails extra effort, but if one wants smokeless combustion with hand firing, he has got to work for it. Pittsburgh might do well to try this method.

Longer Ignition Arches Needed

The report pleads for long ignition arches and favors horizontal baffles. This may be best for all furnaces using Pittsburgh coal, and for furnace using any coal, providing there is sufficient furnace volume obtained by a high setting. The writer has observed that, with ordinarily high settings, boilers horizontally baffled and burning some Eastern bituminous coals have failed utterly to operate at even rated capacity because the furnace temperature was so high as to quickly fuse much of the ash and decrease the air supply by plugging the grate. By changing to vertical baffling or getting a coal with ash that has a much higher fusing point, or exposing the bottom row of tubes, the trouble ceases. Fortunately, most coals do not give much serious trouble in boilers so baffled.

Handfiring Better Than Frontfeed Stoker

The accompanying table, which is a summary of the surveys of 152 plants, shows the surprising fact that the front-feed-overfeed stoker gives poorer results than hand firing, so far as smokelessness is concerned. Thirty-four plants having these stokers under horizontal water-tube boilers, and all except one using Pittsburgh coal, produce smoke equal to or greater than 60 per cent. black (Ringlemann) for an average of 14.6 minutes per hour against 12.2 minutes for 32 hand-fired horizontal return-tubular boilers, while with 18 hand-fired water-tube boilers, the average was 5.2 minutes per hour. Notice that the hand-fired tubular boilers do not have coking arches or dutch ovens as is the case with the hand-fired water-tube boilers.

The reason for the poor results with these stokers, as compared with hand firing and other stokers is, perhaps, due to two chief causes, namely too frequent disturbance of the fire by hand and too short ignition arches placed too near the grate. The last defect may induce the first, for under such conditions the green coal does not coke sufficiently on the dead plate, but volatilizes so rapidly when it gets further down that black smoke is produced. This, with some coals at least, leads to clinker troubles that cause the firemen to disturb the fire frequently, often provoking the trouble.

Locomotive Smoke

Locomotives contribute the second greatest amount of smoke in the district. This smoke is exceedingly objectionable because the stack is so low that the smoke quickly diffuses over a comparatively wide area before it has risen much above the height of the stack. The conclusion is reached that the electrification of yard locomotives especially will be necessary before the ultimate solution of the railroad smoke problem is made.

Mechanical stokers assist in considerably reducing the smoke produced in metallurgical furnaces.

Smoke from boats in the rivers adds comparatively little to the smoke of the district.

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Long Transmission Span—On the long line of the Mississippi River power Co. is a span 200 ft. at the crossing of the Missouri River. The conductor at this point consists of $\frac{5}{8}$-in. stranded steel core overlaid with 20 strands of No. 10 B. & S. hard drawn copper wire. The normal sag is about 150 ft.

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Available Water Power of Ontario—Ontario has many inland lakes, of which the two largest are the Lake of the Woods, with an area of 1851, and Lake Nipigon, with 1730 square miles. The ten most important of these lakes have a total area of 6128 square miles. The numerous rivers and lakes scattered throughout the province, particularly in northern Ontario, afford almost unlimited water power. It is estimated that the total available water powers of the province are sufficient to produce between 4,000,000 and 5,000,000 hp., of which about 1,000,000 hp. had been developed in 1910. It is proposed to retain in the hands of the government as far as possible these immense waterpowers to be developed as needed for the benefit of the people and not for the enrichment of private monopolies.

Massachusetts Boiler Law and Rules--III

By C. J. Andrews

SYNOPSIS—This is the concluding installment of the analytical discussion of the rules drawn by the Massachusetts Board of Boiler Rules.

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Section 4 (continued)

Paragraph 36 permits tested stay-bolt material to be used at a factor of safety of 6.5. This does not appreciably increase the allowable load, except for the smaller sizes of steel stays.

Paragraphs 37, 38 and 39 contain useful and convenient tables, well worth embodying in other rules of the kind.

Paragraph 43 specifies how rivet holes are to be made. The method given is probably as safe and good as drilling the holes from the solid plate, but the latter is practically as cheap and so specifying would relieve the shop inspector from keeping a record of the size holes punched on every boiler to show that the rules were complied with. Often an inspector sees only the finished hole and it is impossible for him to tell whether the required amount of metal has been drilled out or not.

Paragraph 46 requires the calking edge of the plates to be beveled wherever possible. This rule should add that such beveling be done on a planer and not on bevel shears, since shears probably injure the metal as much as punching rivet holes full size.

Paragraph 47 specifies the method of making tube holes. A limit placed on the difference to be permitted between the diameter of tube holes and that of the tubes to be expanded in them would have improved the rule and the boiler's safety.

Paragraphs 49, 50 and 51, dealing with the manner of finishing the tube ends for both fire-tube and water-tube boilers, are very important, both from the standpoint of safety and to obtain good workmanship.

Paragraph 53, giving the minimum number of pipe threads in an opening, is also important. It should, however, be modified to permit of some fittings being bolted to a boiler. The rigid enforcement of the rule as it now stands would cause the rejection of some perfectly good and safe construction, which is even better than riveting the parts together.

Paragraph 56 specifies the material for manhole frames. A number of failures have occurred at this point in the past; similar rules should be made by others.

Paragraph 59 concerns the material for manhole plates. While plates conforming to these specifications may be made lighter than cast-iron plates, still cast-iron is perfectly safe for such use and should not be barred.

Paragraph 60 requires a manhole located in the front head below the tubes, in a boiler 60 in. in diameter or over. There has been considerable criticism of this rule on account of this requirement, due to the fact that, in New England, the feed water is of exceptional purity, and it has been customary to place only handholes below the tubes and some of the New England boilermakers objected to changing this practice. In other sections, the conditions are quite different and it is necessary to have a manhole below the tubes to afford access for cleaning.

Ohio rules specify that manholes must be placed below the tubes in all boilers 48 in. or more in diameter. This is the safest plan to be adopted by others because the manhole can do no harm and at times is a necessity.

Paragraph 62 requires a handhole in the rear head below the tubes, in all boilers not having a manhole below the tubes. Such hand-holes are so troublesome that the wisdom of this rule is doubtful. They greatly facilitate cleaning, but have also been the means of ruining many boilers. All boilers of this type should have manholes below the tubes, except those of very small diameter, extra-wide spacing between the center tubes and ample space between the shell and tubes at the side would avoid the necessity of having handholes in the rear heads below the tubes.

Paragraph 66 requires at least 1 in. of solid metal, in the clear, around a handhole opening, except where the plate is $\frac{7}{16}$ in. thick or over, when the prescribed amount is reduced to ½ in. The only good reason for this rule seems to be that plenty of metal to work on makes repairs easier where corrosion has eaten away the metal below a handhole opening on a vertical or locomotive-type boiler. However, if this is its purpose, there is no logic in reducing the allowance in the case of the thicker plates.

Paragraphs 67, 68, 69 and 70 specify that boilers over 78 in. in diameter be supported by hangers and columns, independent of the setting walls. This rule has been criticized some, but is good and might even make the minimum size 72 in.

The reduced shearing strength allowed on rivets that attach lugs and brackets to boiler shells is justified. There should be a rule regarding the design of the lugs and brackets, so that the load on the rivets is evenly distributed. A lug may have plenty of rivets, if all were in service, so that the stress per rivet would be low, but if the design is such that only two or three rivets act together, the stress per rivet may be dangerously high. A reasonable stress per rivet is also necessary, because the stress is transmitted directly to the shell in such a way that it is added to the tensile stress on the shell, produced by internal pressure. Probably many explosions of horizontal return-tubular boilers are due to abnormal stresses in the vicinity of the supporting lugs.

Paragraph 71 makes it necessary to have the top of the grates above the leg ring in locomotive and vertical tubular boilers. This is a good rule.

Section 5

Paragraph 1 of this section prohibits a safety valve being connected to an internal pipe placed in the steam space of the boiler. This rule would be more definite, if stated about as follows: A dry pipe, or other internal device, must not be attached to a steam outlet to which safety valves are attached.

Paragraph 2 specifies that safety valves for superheaters must be placed at or near the steam inlet, whereas they should be placed at or near the steam outlet, to properly protect the superheater from overheating. The State of Wisconsin so specifies the location in its proposed rules.

Paragraph 3 requires all boiler connections over 2 in. in diameter, except the safety-valve connection, to have a stop valve near the boiler, which must be of the outside screw and yoke type. This is a good rule, intended to promote safety and should be copied.

Paragraph 5 requires two stop valves on all boilers set in a battery when a pressure greater than 135 lb. is allowed on any of the boilers. This rule deserves a place in all rules to promote safety, but the highest pressure allowed, without two valves, should be 25 lb. and the rule should read: "Where two or more boilers are connected to the same steam-pipe system, two stop valves, etc." A rule should require suitable locks and chains, for the blowoff and main steam valves, so that they may be locked closed on each boiler undergoing repairs, cleaning or inspection. Fatal accidents, caused by turning hot water or steam into idle boilers, are frequently occurring and a strict rule of this kind would tend to reduce the number of such accidents.

Paragraph 6 gives the minimum number of threads that a pipe or nipple must screw into a fitting. This is a good rule, for it avoids any controversy between the inspector and the owner.

Paragraph 7 provides two stop valves on boilers set in a battery and superheating the steam more than 80 deg. Specifying double valves, as has been previously recommended, would cover this case.

Paragraph 8 specifies that, when a globe valve is used on the feed line to a boiler, the inlet shall be under the disk. This protects against the valve coming loose from the stem and closing off the feed.

Paragraph 9 requires the feed water to be discharged about three-fifths the length of the boiler from the front head, except when a boiler has an auxiliary feed-water heating device. It is open to question whether this location can be considered the best.

Paragraph 10 seems to fully cover the situation in regard to the proper point for the discharge of the feed water.

Paragraph 12 pertains to means of feeding a boiler of over 50-hp. capacity. The rules are rather weak in this particular, for, as already pointed out in discussing Part II of the rules, the only need is that some means be provided to feed the boiler against the maximum pressure allowed; where the local water-supply pressure is high, a connection to the system may be the only means used to feed the boilers. If a boiler user should decide to have a reserve pump or injector as an additional safeguard, he would have to put in two such devices, to comply with the law, although he could leave off both without violating it. A better rule would be about as follows: "When boilers are to be operated at a pressure greater than 25 lb., they shall have two or more means of feeding, each capable of delivering an amount of water corresponding to at least twice the maximum rated boiler capacity, against the maximum pressure allowed, except in plants having three or more boilers where a reserve feeding apparatus 50 per cent. in excess of the rated capacity of the plant, will be considered sufficient. When the water supply for a boiler may be drawn directly from a water system, and the average water pressure is 20 per cent. greater, at the connection to the boiler than the steam pressure allowed, the water system will be considered as one of the methods of feeding the boilers."

Paragraph 13 requires the temperature of the feed water entering a boiler to be not less than 120 deg., when the pressure allowed exceeds 25 lb. This is a good rule and should be copied by others.

Paragraph 14 limits the maximum size of a surface blowoff to 1½ in. This does not interfere seriously with the use of a blowoff of this description. Still, there seems no reason why a surface blowoff should not be permitted as large as a bottom blowoff connection.

Paragraph 15 prescribes the sizes for bottom blow-off connections from 1 in. to 2½ in., and these are good limits to be followed. A globe valve on a blowoff connection is prohibited, which is also wise.

Paragraphs 16, 17, 18, 19 and 20 all relate to blowoff equipment and are all good.

Paragraphs 22 to 26, inclusive, deal with the water-column equipment and are good, except that, if valves had been entirely prohibited on the water-column connecting pipes, instead of requiring that they be locked or sealed open, the safety of operation would have been increased.

Paragraph 29 states that steam reservoirs are required on mains where heavy pulsations cause vibrations of a steam pipe. This rule should specify the size of reservoirs required, for, in its present form, it is of no value whatever, and it is doubtful if it could be enforced.

SECTION 6

Section 6 deals entirely with installations that are not standard or that were in the state at the time of the passage of the law. It is, of course, impossible to make a set of boiler rules as complete as those of Massachusetts and expect that every boiler that is made, or comes into the state, will be constructed in exact accordance with them. It was soon found that a number of boilers came into the state that did not comply fully with the rules. This was not on account of any attempt on the part of the manufacturer or owner to evade the law and it was recognized that some way should be provided, so that these boilers might be used, therefore *Paragraph 1* of Section 6, in a little different form from that now used, was added to the rules.

This paragraph provides that when an owner, or prospective owner, of a boiler that does not comply with the rules, desires, he may apply to the board of boiler rules for a permit and that such a boiler may be installed after an inspection by a member of the state boiler-inspection department. The lowest factor of safety that may be used in fixing the pressure on such a boiler is 5.5, and the longitudinal joints must conform to the requirements as given in the rules. Some provision of a similar character should be made in every law, but care must be exercised that all such boilers are penalized, for unless this is done, too many such boilers will be submitted for consideration.

Paragraph 2 provides for the reinstallation of boilers that were in the state at one time, and later removed. Under such conditions a certificate may be issued after an inspection by a state inspector or one holding a certificate as an inspector of boilers for the state. This was another provision, to prevent interference with property rights.

Additions to the Rules That Might Have Good Effect

The Massachusetts rules could be materially reduced in number, for many are not directly concerned with safety. Also a number of rules might be added to advantage, besides those that have been mentioned in this discussion. For example, there are no rules to govern the construction of domes for boilers, although the rules do not prohibit their use. The Board of Boiler Rules would have been justified, if it had prohibited the use of domes on all boilers built for use in the state after the passage of the law. Unless a boiler dome is properly designed, especially with respect to its attachment, the shell of the boiler is likely to be dangerously weakened. This has led to many serious boiler explosions.

As already mentioned, the rules do not cover furnace design, where other than staybolted furnaces are used and this is very important. Some rule should be adopted to permit a limited amount of pressure on the heads of boilers and similar surfaces, without requiring that they be braced.

A rule which would reduce one class of accidents, would specify how the discharge end of blowoff pipes must be arranged. Another provision, that would tend to safeguard lives, would be that the fire-doors of water-tube boilers open inwardly or at least have substantial latches, so that the attendants would be exposed to danger from tube failures only while the fire-doors were being used.

A good rule would require the pipe connecting the steam gage to a boiler to be at least ½ in. in size and of brass up to the point where it is connected to the water-column piping or the boiler. A number of explosions have been traced to the combination of a defective safety valve and a defective gage; often the trouble with the gage has been that the connection to the boiler has been stopped with rust scale. Sometimes little time is required for a ¼-in. iron pipe to become completely stopped.

Safety valves should be required to be equipped with means to permit of their being tested from the engine-room floor. The top of a boiler is a disagreeable place, especially in summer, and only by providing reasonable means for testing valves, can it be expected that this duty will be attended to. A rule fixing a minimum height for the space over boilers would be quite desirable.

A rule specifying seamless drawn tubes of heavier gage than the standard, for water-tube boilers on which high pressure is to be carried, would tend to eliminate some of the tube accidents that are now frequent. A rule requiring that gage glasses be properly protected, would tend to safeguard the eyesight or life of plant operatives, for the breaking of a gage glass has been the cause for the loss of life.

Conclusion

In conclusion, it may be again repeated, on account of its importance, that rules to govern boilers already in service, should be given the most careful consideration, because it is these rules that will meet the opposition of steam users and if they are not strictly just, or necessary for safety, they will not stand the test of public opinion.

Nashville Rules for Heating Boilers

The department of smoke inspection of Nashville, Tenn., has adopted the following rules prescribing the quality of fuel, style of furnace, and sizes of stacks for heating boilers:

1. In all firebox boilers up to 1500 sq.ft. capacity, coke or coal with less than 20% volatile matter must be used.

2. All firebox boilers above 1500 sq.ft. rated capacity must be provided with downdraft furnaces.

Stack Sizes

3. The least dimensions allowed for stacks of boilers of various sizes are as follows:

Square Feet of Boiler-Heating Surface	Stack Sizes
Up to 500 sq.ft.	9 in. x 9 in. x 40 ft.
500 to 1,000 sq.ft.	12 in. x 12 in. x 45 ft.
1,000 to 1,500 sq.ft.	12 in. x 12 in. x 50 ft.
1,500 to 2,500 sq.ft.	16 in. x 16 in. x 60 ft.
2,500 to 3,000 sq.ft.	20 in. x 20 in. x 60 ft.
3,000 to 3,500 sq.ft.	20 in. x 20 in. x 65 ft.
3,500 to 3,800 sq.ft.	20 in. x 20 in. x 70 ft.
3,800 to 4,200 sq.ft.	20 in. x 20 in. x 75 ft.
4,200 to 6,500 sq.ft.	24 in. x 24 in. x 75 ft.
6,500 to 8,750 sq.ft.	24 in. x 24 in. x 80 ft.
8,750 to 10,000 sq.ft.	28 in. x 28 in. x 80 ft.
10,000 to 10,500 sq.ft.	32 in. x 32 in. x 80 ft.
10,500 to 13,000 sq.ft.	32 in. x 32 in. x 90 ft.
13,000 to 14,000 sq.ft.	36 in. x 36 in. x 90 ft.
14,000 to 14,500 sq.ft.	36 in. x 36 in. x 95 ft.
14,500 to 15,000 sq.ft.	36 in. x 36 in. x 100 ft.

4. The above stack sizes are for boilers which are set not over 10 ft. from the stack, counting from center of stack to back of boiler, and allow for only one right-angle turn in the smoke connection; for each additional right-angle turn add 10 ft. to the height of the stack.

5. These sizes are for cases where only one boiler is connected to the stack, and where there are no openings in the stack for other purposes.

6. Where more than one boiler is used, or where other apparatus is connected to the stack, each case will be passed on separately.

7. In all cases stacks must be carried above the topmost story of the building.

8. The top of all stacks must be at least 12 ft. higher than the roof of any building within 50 ft. of the stack.

9. Every stack not directly connected must have a clean-out door at its base at least 24 in. square. A stack less than 24 in. square must have a clean-out door of the same area as the cross-sectional area of the stack.

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Coal Production in North Dakota in 1913—Although the production of coal in North Dakota in 1913 was only 495,320 short tons, valued at $750,652, some interesting facts regarding the possibilities of the vast deposits which underlie the state are shown in a statement by E. W. Parker just made public by the United States Geological Survey. All the present mineral fuel produced in North Dakota is brown coal, or lignite. Considerable areas of subbituminous coal of usable quality and workable thickness are believed to underlie portions of the lignite areas, but no attempt to exploit the subbituminous coals has been made. At present the lignite is used chiefly for domestic purposes, but with proper equipment it can be used with satisfaction as a boiler fuel. A convincing example of what may be accomplished with lignite for such use is presented by the irrigation plant of the United States Reclamation Service at Williston. The lignite used here is taken from the only coal mine owned and operated by the Government. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be recognized as possessing great potentialities in the settlement and economic development of the state. Experiments also show that lignite can be successfully briquetted, after which it stands transportation well and its heat value is increased 50 to 70 per cent.

Editorials

Engineering Problems in Handling Pittsburgh's Smoke

Congratulations are due the Mellon Institute of the University of Pittsburgh for its latest bulletin, "Some Engineering Phases of Pittsburgh's Smoke Problem." It is, we believe, the best report yet published on the engineering phases of the smoke problem of a city. Heretofore, most of the Institute bulletins have dealt with smoke and its relation to the damage to laundry, buildings, vegetation and its psychic effect upon individuals. Unquestionably, these bulletins have made the citizens of Pitsburgh realize that smoke is very expensive and disagreeable, but they have not excited the enthusiasm of the engineer. The present bulletin, however, is most commendable and well worth studying.

Our review and comment on page 343, suggest many interesting thoughts on the causes and abatement of the smoke evil. Of the one hundred and fifty-two plants observed, the results again confirm the ability of the underfeed type of stoker to give smokeless combustion when properly handled. It comes as a surprise that the front-feed overfeed type of stoker under water-tube boilers should have failed to be as good as hand firing with horizontal tubular boilers and quite some worse than hand-fired water-tube boilers equipped with dutch-oven furnaces or having horizontal baffling. The probable reasons for the failure are brought out in our comment.

One cannot read the report without again being reminded that plenty of available cheap fuel is sometimes an evil as well as a blessing to a large city, for as long as it is cheap, gross negligence and resulting smoke accompany its use.

We agree with the report that for the coal used, stokers should be placed in plants of three-hundred horsepower and over.

Association Educational Work

Again the season is here when engineering organizations begin their annual educational work. As much money, time and energy will be spent for this purpose, the results should equal a commensurate return on the investment.

No matter what the nature of the work may be, but particularly if the season opens with mathematics, be sure to start low enough so that the lessons are not "above the heads" of most of the members. Those in charge of educational work are usually appointed because they are better fitted than the average member. For this very reason, they must be cautious that their methods and lessons are adapted to the majority of the class; the natural tendency is to make the lessons too advanced.

In the average organization of power-plant men, the greatest good comes from the discussion that follows a lecture. Usually, the subject is so broad that the lecturer can touch on the most essential points only. While matters of detail bearing on the merits of different methods of doing a given job or operating a certain machine are most often brought up by the members, there is still far too little of this kind of discussion, and it is the very best, too.

This leads to that most delicate of problems in conducting engineering educational work, namely, overcoming timidity. Many men who need information are so timid that even the thought of getting up and asking for it during a meeting unnerves them. This is true also of many who are equipped to give information. It requires tactful and persistent effort to clear the meeting room of this dread. Where timidity is the cause for lack of discussion, the use of a question box, hung in the outer hall, where a man may drop in his question unobserved, will do much to get good questions before the meeting.

The most useful, and generally the least used accessory, is the blackboard. When a member gets up to make explanations which would be clearer if illustrated or worked out mathematically, he should be requested to "put it on the blackboard." If this occurs frequently in the meeting, it will not be long before the members will step to the blackboard without being requested.

Learning a Trade

Often a father says that his boy shall have a trade to fall back on in case he is not successful at something else. This implies that anyone can succeed at a trade who might fail as a professional man or along commercial lines.

Such an implication every workman should resent. A trade should be a stepping stone to something better at which there is still further chance of success. Of the successful manufacturers, the larger part have come up from a trade. To them a trade was a stepping stone, not a thing to fall back on. Learning a trade, if it is learned at all, is a life job. Learning enough to hold a job at a living wage for even a small family takes time that can hardly be spared by anyone who intends to take up a profession. "Better put all your eggs in one basket, and then watch the basket."

On the other hand, as a preliminary to a technical course, it is an advantage to a young man to have worked as a machinist, if he is to be a mechanical engineer, in a power plant, if he is to specialize along that line, or in a civil engineer's office, if that is the direction in which he is headed. He will get a clearer idea of what he is going to encounter, and what he will need to know, than he can by going to school first. He will find that his technical course will divide itself into two parts, things which he should comprehend and be able to work up in detail by himself later, if occasion should demand, and things which he must make his own to use as working tools every day of his professional life. In the first he can afford a few low marks, in the second he cannot. If he has had enough experience to discover what an engineer in his line uses for tools, he will be in a position to get his engineering education first, keep his health next, and get all the cultural and collateral education that his head will carry last.

The tools of the engineer he will find in all branches to consist mostly of principles. He may not be able to comprehend principles except as he sees concrete illustrations of them around him. Educational methods are being more and more centered around the concrete illustration, but the young man must learn to think in the abstract, to divest his problems of all but the bare bones before he begins their analysis, and then to work them out, adding to them the concrete surroundings, which came with them.

The only danger to a man who uses a trade as a stepping stone to an education is that while he is working with his hands his brain may be rusting. Conventional educational programs are built around an ability to pass examinations, which are not education at all, but only a sort of exhibition of mental alertness. The fact that examinations must be passed and that they must be led up to through study of books, is something that he must not overlook, and something that will lead him to keep up his reading evenings even when he comes home tired out and better prepared for some lighter amusement.

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Wisconsin Has a Boiler Code

The State of Wisconsin has a boiler code, which is administered under the Industrial Commission law of 1913, one section of which expressly authorizes the commission to fix and collect fees for the inspection of boilers, not exceeding $2 for each external inspection, and $5 for each internal inspection, per annum, and to collect fees for the inspection of elevators, not exceeding $2 semi-annually for inspection. The commission may accept inspections of boilers and elevators by qualified inspectors of insurance companies, where such boilers or elevators are insured, in which case no fee shall be charged. The commission may also accept inspections by qualified inspectors of boilers or elevators in cities of the first, second and third classes, in which case the city may collect and retain such fee for inspection as may be fixed by the commission for its own inspection.

The code which has just been issued by the Industrial Commission saw its first practical beginning in a conference of boiler maufacturers, insurance representatives, municipal inspectors, and representatives of boiler-using interests, held at the instance of the Industrial Commission of Wisconsin in the Chicago City Hall on January 5, 1912. The object of the meeting was to discuss the formation of a standard code of rules for the building and operation of boilers, together with a means of boiler inspection which should be acceptable to the commission and to all concerned. The result of the conference was the appointment by the commission of an advisory board of boiler rules with power to formulate and recommend a code of boiler rules for Wisconsin. The first result of the labor of the board was the publication of tentative boiler rules, on which a public hearing was held on October 30 of last year. The rules as now issued, and which appear upon a cursory examination to follow very closely those of Massachusetts and Ohio, are the result of that discussion. The Industrial Commission law contains a section authorizing it to investigate, ascertain and determine such reasonable classifications of persons, employments, places of employment and public buildings, as may be necessary to carry out the purposes of the act, and it would seem that under this provision the examination and licensing of those engaged in the operation of power-producing apparatus might be brought about.

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Getting Out of the Rut

In engineering, as in other fields generally, there is inertia with regard to trying new things. The tendency is to "do as we did before," rather than experiment.

Modern practice, to a large extent, must be based upon past experience, but experience is responsible for a great deal of "mind laziness."

Engineers sometimes get ideas fixed in their minds which are detrimental to progress in designing for greater efficiency.

Rather than acknowledge that a certain thing would require thinking about, and probably a little ingenuity and calculation, which he is loath to give it, an engineer will discuss it with the remark, "What did we do before under similar circumstances?" or "It worked so well before, why shouldn't it do so again." All argument as to efficiency in such instances usually has the effect of leaving a bad impression in the mind of the engineer with regard to the other party in the discussion. The engineer has a good deal at his back when he has it done as before, but it is scarcely acting up to his position as engineer to be only a copier.

He takes no chances and is perfectly safe in what he does, nevertheless, unknown to himself, he does harm in stunting the growth of the mind and initiative in his subordinates.

After a few experiences of the kind, the subordinate thinks, "Well, I could improve on that, but what's the good." If he actually works his idea out, it rarely sees daylight in constructed form, and if it does it is generally to the credit of the engineer. The future of engineering depends less upon past experience than upon men who have the strength of mind to think along different channels and get out of the old ruts. It is easy traveling along the well worn ruts, and it takes courage to quit them, but it pays to be progressive even at the expense of inconvenience. If it doesn't always take the engineer to the goal he is after, it develops his character and ability at any rate.

Discussion of fresh ideas does not always mean discarding old ones ,in fact, it often brings out and emphasizes good points in them. It is, however, necessary to progress of any kind and a half an hour's discussion, even if it leads nowhere, broadens the minds of those participating in it and hence is not by any means wasted time.

So it behooves engineers in general to be very chary in the use of the expression, "What did we do before," as such an expression generally vetos all discussion.

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At the time of going to press the convention of the American Boiler Manufacturers' Association is still in session, so that we are compelled to withhold the report of the interesting discussions on uniform boiler specifications until next week.

Correspondence

Operating Underfeed Stokers

During the past three years, I have operated underfeed stokers in a manufacturing plant. Therefore, I was much interested in J. C. Hawkins' article in the July 21 issue.

It was necessary during two of the three years that we carry at least 200 per cent. rating on the boilers continuously; also as our coal was being purchased from several dealers, we could not count on a uniform grade. The first few months we experienced troubles similar to those described by Mr. Hawkins. At first, we were inclined to condemn the stoker, but then it occurred to us that if it was an inherent weakness, this type could not have been adopted as standard by practically all large power plants. We first studied the design. It is quite evident that the stoker is to feed the coal in from the front and, as it burns, to slowly move it backward and downward toward the dump plates; to have it burned out to ash when it is deposited on the dump plates, and then periodically dump the ash and refuse.

Starting with no prejudices and forgetting our past experience, we failed to find any reason why the stoker could not be operated in this manner, thereby making all barring of the fire unnecessary. The problem then was to actually do it.

We soon found that our trouble had been due to our own ignorance. After making a careful study of the equipment and the necessary adjustments, we have eliminated all trouble. At one time a clinker was formed extending from one furnace wall to the other. This occurred only once and was caused by careless operation. Naturally, the first observations were made when cleaning the fire. By carefully watching the conditions and observing the clinker formation on the dump plates, and also extending beyond the dump plates up into the fire, it was believed that the clinker extending from wall to wall had been formed from the dump plates up and not by building from one wall to the opposite wall. All subsequent observations have further proved this fact.

After cleaning the fire, the fuel bed moves forward until the dump plates are covered, and the ash and refuse naturally forms into a clinker which lies directly on the dump plates. When this clinker becomes a certain thickness, it then begins to form back into the stoker proper, and if continued a sufficient length of time, the unburned fuel is deposited on top. This clinker prevents the air from penetrating through the fuel bed, and therefore the coal and coke on the clinker is not burned satisfactorily. This condition is temporarily overcome by stirring the fires with bars. As this remedy is only temporary, the use of bars again become necessary. Constant barring soon builds a thick clinker a considerable distance up into the stoker, extending from wall to wall. In addition, the barring tends to make smoke and to throw cinders. The remedy is quite obvious and simple: Clean the fire at shorter intervals, so that a clinker can form a short distance only above the dump plates.

The cycle of events is about as follows: Clean the fire by dropping the dump plates (not by barring the fire), then for a short period use a longer, lower ram stroke, thereby quickly pushing the short projection of clinker which remains above the dump plates on the dump plates. Then run under normal stroke conditions until the next cleaning period, that being when the clinker lying on the dump plate extends a short distance only beyond the plate.

By careful observations for a few days, these cleaning periods can be definitely fixed and the work will be easily and quickly accomplished. The only use for a bar is to break off any part which may stick to the bridge wall; which is infrequent. Bars are unnecessary except to clean the side walls once in twenty-four hours, and their use for other purposes leads to worse clinker troubles.

The formation of side-wall clinker is also materially decreased by operating in this manner, doubtless due to a freer motion of the fuel bed toward the rear of the stoker. If the dumping periods are fixed correctly and the right proportion of air and coals used (which is readily determined), there should be no smoke when cleaning the fires.

The results obtained by this method of operation have been most gratifying and have shown a marked increase in evaporation per pound of coal; furthermore, this is being done with scarcely any hard manual labor. Any trouble from clinkering on the tuyeres is due to faulty operation because, properly operated, there can be no condition to cause clinkers other than a slight burning of refuse, which is in no way objectionable; as a matter of fact, it forms a protection against burning a tuyere.

Small handhole openings are provided in the wind box for inspection and any small quantities of coal which might sift in can be readily cleaned out through these openings. The condition of the interior of the stoker also can be determined by periodical inspections. A large quantity of sifting indicates at once that something is probably burned in the stoker; it is not necessary to burn out the fire to determine if the interior of the stoker required repairs.

No trouble has even been experienced in carrying banked fires for a week. The method pursued is as follows: The fire is not cleaned previous to banking. When banking, the air is shut off and one hopper full of coal is fed in. The boiler damper is then closed as tightly as possible; boiler dampers never fit absolutely tight and the leak around the damper will carry out any gases formed during the banked period. One hopper of coal is usually sufficient to maintain a banked fire from thirty-six to forty hours, thereafter, a little coal is fed in from time to time. The ash is also dumped during the banked period. In starting up from the banked fire, the stoker is first dumped and then started, using the long stroke of the ram for several revolutions, before any coal is fed in the hopper, the hopper having been left empty at the time of banking.

As the load varies through wide limits, it is necessary to have a wide range of operation in the regulating mechanism. This range is cut down to as narrow limits as possible, the high speed being controlled by the governor and the low and intermediate speeds by the regulating valve. After settling on the correct time between cleaning, the result is that the fires are always clean and free from excessive ash and clinker. This has apparently brought the necessary limits of speed closer together and considerable less air pressure is now needed to carry the same load on the boilers.

There has never been any objection to cinders issuing from the stack. The cinders collected behind the bridgewall, however, have been materially decreased by narrowing the fluctuations in speed and by maintaining as low natural draft over the fire as possible without blowing fire and gases out of the furnace doors. Cinders from the stack in sufficient quantity to be objectionable are no doubt due to large amounts of ash in the fuel bed (caused by too infrequent cleaning), making high air pressure necessary to burn out the coal.

In operating any automatic stoker it must be borne in mind that the essential idea is its automatic design, and that the application of hand-fired principles is not a remedy for conditions due to improper operation.

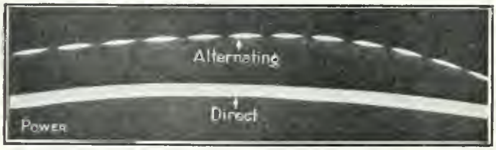
STANLEY O. LARGE.

Philadelphia, Penn.

Photographing Alternating and Direct Currents

The accompanying photographs were taken of an arc lamp of the multiple 110-volt type, the lamp being placed in a room with all other lights out. The operator then placed the camera in position against his chest and swung it rapidly in a horizontal plane with the shutter open. The relative intensity of the arc was so great as to render the image very sharp.

The upper photograph shows clearly the alternations of the alternating-current arc, the zero points of the current being represented by the breaks in the strokes. The peak is also shown at the center of each, with the ends gradually tapered. Each of the light strokes represents a complete alternation (two represent a complete cycle) and the photograph shows six cycles.



ALTERNATING AND DIRECT CURRENT AS RECORDED ON A PHOTOGRAPHIC PLATE

The time required to photograph the 12 alternations may be easily figured. The circuit was 60 cycle and six cycles are shown, hence the time required must have been $\frac{1}{10}$ sec.

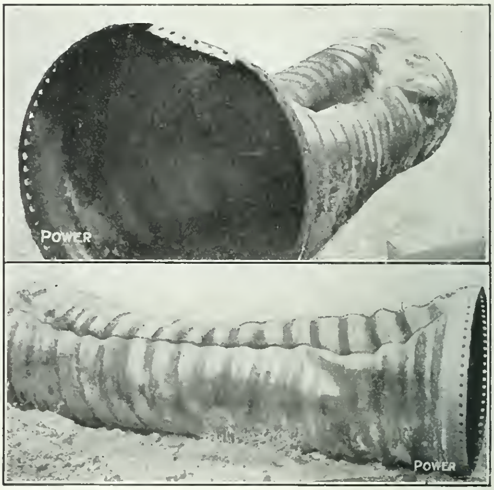
The lower view is of the same arc lamp supplied with direct current. A continuous streak of light is here shown, as would be expected, the greater width being due to a longer arc.

J. B. LINKER.

Charlotte, N. C.

Blowoff Valve Left Open

The illustrations show the condition of a corrugated furnace taken from a Scotch marine boiler in the power plant of the Utah Fuel Co., Castle Gate, Utah. After blowing down, the fireman forgot to close the blowoff valve. When next observed, the boiler was practically dry and only the arrival of the chief prevented the introduction of cold water into it. They closed the valve in the steam takeoff to the main header and pulled the fire. When the flue was removed it was found to have a huge wrinkle the full length as shown but not a crack could be found in the metal.



FURNACE AFTER REMOVAL

RANSOM S. HAWLEY.

Ludington, Mich.

Oil Soaked Coils

A short time ago, I was called upon to dry out the electrical machinery in a small hydroelectric plant of 375 kv.-a. capacity. The alternators were three-phase, 2200-volt, 60-cycle machines one 150 kv.-a., and one 225 kv.-a. This plant is protected against high water by a high concrete wall and a large sump pump. The river rose very rapidly on this occasion, and the water came over the wall, filling the power house slowly to a point just above the bearings of the 150-kv.-a. machine, but not high enough on the other generator to float the oil out of the bearings. The lower coils of the smaller unit were soaked, and as there was no current through the building, the oil from this machine floated around it while the water receded.

On account of other damage to the plant, it was impossible to start drying out for five days after the flooding. The generators were then dried in the usual manner, by short-circuiting the armature leads and passing a heavy low-voltage current through the winding. There was no means at hand for testing the insulation resistance, and at the end of eight days the larger unit was put in service. It has given no trouble. The other machine was kept on short-circuit run for three weeks, and then put on the line, two coils burning out after 14 hours' running. On taking the damaged coils out, they were found to be still very wet, so the machine was again short-circuited and run for another week. It was then put on the line again and one coil burned out after a twelve-hour run. Upon investigating, we found that all the coils in this machine that were submerged were wet, and that the outside layers of taping were thoroughly impregnated with the oil from the bearings, making it impossible to drive out the water which was in the inner wrappings. The wet coils were then taken out, the old tape removed and the coils dried by baking. On retaping and replacing the coils in the generator, the trouble disappeared. The lesson to be learned from this experience is, to take the oil out of the bearings before leaving the machines.

D. D. Smalley.

Bagby, Calif.

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Calculating the Strength of Diagonal Boiler Joints*

Calculating the strength of diagonal boiler joints accurately is rather difficult, unless one is familiar with trigonometry. It is fortunate, however, that for the angularity of such seams with the length of the boiler as usually found, a close approximation to the true value can be obtained in a simple manner. In order to avoid confusion, it should be understood that the efficiency of a joint should be considered the same whatever its position, for it should express its strength as compared with that of the solid plate, and this ratio does not change, no matter what its position on the boiler shell.

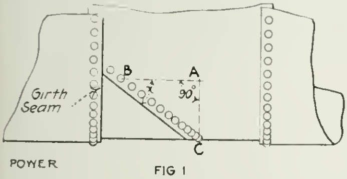

FIG 1

Fig. 1, Rule 1.

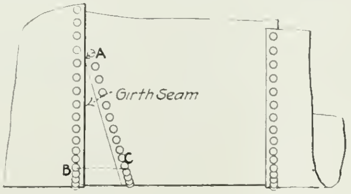

FIG. 2

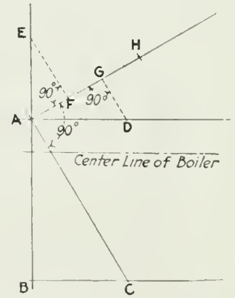

FIG 3

Fig. 2 and 3. Rule 2.

If a boiler has a patch with a diagonal seam, as shown in Fig. 1, the question to be determined is not the efficiency of the seam BC, but the relative strength of this seam to resist internal pressure as compared with the solid sheet along a line parallel with its length. In all cases where angle x is not over 45 deg., this relative strength of the diagonal seam and that of the solid plate along a longitudinal line can be determined, with a maximum error of about 3 per cent., which occurs when the angle x is 45 deg.; at 30 deg., the error is only $\frac{1}{10}$ of 1 per cent. This method (Rule 1) consists of finding its efficiency in the usual manner and multiplying it by the result found by dividing length BC by length BA. Thus, if the efficiency of seam BC was 52 per cent., and the angle of the seam to the length of the boiler was such that the distance from B to C was 25 in. and B to A was 20 in.; then

$$0.52 \times \frac{25}{20} \text{ or } 0.65$$

would represent the strength along BC as compared with the strength of the solid plate along any horizontal line, as BA.

The reason an inaccuracy results in calculating joints of greater angularity is that, as they approach the vertical position, the effect of the longitudinal stress (which affects the girth seams of a boiler) comes into play. In the above calculation, no account is taken of the stress lengthwise.

In order to avoid mathematical formula, a graphical method for determining the strength of diagonal seams where angle x is over 45 deg. will be given (Rule 2), which can, of course, be used for joints of any angle, if the method already given is not sufficiently accurate. If the strength of a seam AC, Fig. 2, is desired, first figure the efficiency of the seam along AC in the usual manner; then draw line BC parallel with the axis of the boiler and measure the lengths of lines AB, AC and BC. It does not matter just what length is chosen for AB, but it should be long enough to make accurate measurements possible, say, 18 to 24 in. When this has been done, reproduce triangle ABC (on a drawing board or other place where lines can be accurately made), as Fig. 3.

Through A, line AH should be drawn perpendicular to line AC, and line AD should be drawn parallel to the axis of the boiler and AE as a continuation of the line representing the girth seam of the boiler. Now, dividing AB by $2AC$, a certain result is obtained. This should be laid off as a distance from A to E, using any convenient scale, similarly dividing BC by AC, another result is obtained, which should be laid off as AD, to the same scale as used in laying off AE.

From D and E, perpendiculars should be dropped on line AH as shown, and the distance from A to F should be laid off beyond G as GH. Now, the distance from A to H represents a value (when estimated by the same scale as used in laying off AE and AD). By dividing the efficiency of the seam along AC by this value, the result will be the relation between the strength of the solid plate along the length of the boiler and the strength of the seam along AC when the boiler is subjected to internal pressure.

The above explanation sounds complicated, but a numerical example will show that it is not really so.

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*See also "Patching Boilers," Aug. 25, pages 275 and 280, and this issue, page 355.

Assume $AC = 20$ in., $BC = 10$ in. and $AB = 17.3$ in.; then

$$\frac{AB}{2\,AC} = \frac{17.3}{40} = 0.433$$

and this would represent the distance AE, which is laid off in inches on a scale of 4 in. equals 1 in the figure.

$$\frac{BC}{AC} = \frac{10}{20} = 0.5$$

which is laid off as AD to the same scale of 4 in. equals 1. Now it is a simple matter to drop the perpendiculars EF and DG on line AH, and by adding the distance AF to AG, we have 0.656 as the length of AH measured by the same scale of 4 to 1. If the joint along AC had an efficiency of 50 per cent., its strength with respect to that of the solid plate along AD would be

$$\frac{0.50}{0.656} = 0.762 \textit{ per cent.}$$

This means that the strength of the boiler along the seam AC is the same as if this seam was longitudinal and had an efficiency of 76.2 per cent. These seams have been figured as if they were located on a plain cylinder, and the internal pressure was free to produce a stress lengthwise as well as girthwise of the boiler. In the case of the horizontal return-tubular boiler this is not true, since the tubes and through braces support the heads and relieve the shell of a very considerable portion of the load, due to the pressure on the ends of the boiler.

It will be seen that the method here described for obtaining the strength of diagonal boiler joints is merely resolving the longitudinal and girthwise stresses to obtain their components at right angles to the direction of the joint; that the reason for dividing AB by $2AC$ is because the longitudinal stress is one-half that girthwise of the shell.

J. E. Terman.

Hartford, Conn.

⁂

Cost of Operating a Vacuum Ash-Handling System

The articles* relative to suction ash-handling equipment were read with interest, as at the plant under my supervision an ash-handling plant of the suction type was installed about four years ago.

Seven cents a ton, the figure quoted in the issue of July 7, seems so low that it must cover only part of the removal costs per ton of ash, as it is less than half what our removal power costs us—14.6c. per ton, and the power costs 1c. per kw-hr.

The original specification for this equipment called for 20 tons per hour, but on test it only handled about 10 net tons. Under everyday use, 2½ to 3 tons is about the limit.

The piping has been renewed twice in four years, and the depreciation on this end of the system is 50 per cent. The wearing backs in the elbows last from three to four months; no repairs have been made to the tank, but it has been painted twice.

In the boiler plant are four 450-hp. and six 375-hp. water-tube boilers. The amount of ash handled per year is 2500 tons

The average yearly charges are 36,500 kw., at 1c. per kw., $365, which divided by 2500 tons makes a power cost of 14.6c. per ton. Labor for the year is $1186, which divided by 2500 tons makes the labor cost 47.44c. per ton. The average cost per year for repairs for the four years was $1106, which divided by 2500 tons makes the repair cost 44.24c. per ton. The interest charge on the original investment, $7800, at 6 per cent., is $468, which divided by 2500 tons makes the interest 18.72c. per ton.

Taking the per-ton costs, we have, power, $0.146; labor, $0.4744; repairs, $0.4424; interest, $0.1872, making $1.25 the total cost per ton of ashes removed. A skip and hoist could remove ashes for a much lower figure.

Alexander Arnois.

Philadelphia, Penn.

⁂

Packing a Worn Rod

Edward T. Binns described on page 106, July 21, a packing for a worn rod. The way I pack worn pump cylinders can also be used in packing a worn rod. Use hard brass spring rings about $\frac{1}{16}$ in. thick and about two-thirds the width of the packing rings. Cut the packing the proper length, place the brass ring over the packing, and insert both into the stuffing-box. When in place, the packing should be as shown in Fig. 1; Fig. 2 is an end view.

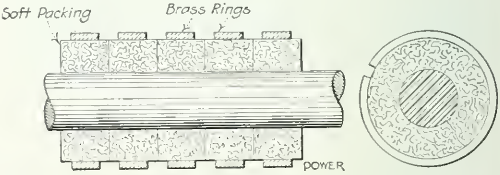

FIG I FIG. 2

Packing and Brass Rings in Position

It will be found that the packing will conform to the different diameters of the worn rod without excessive friction, as the brass rings will yield as the rod passes through the stuffing-box. I have described this same design, reversed in position, to be used on plungers of inside-packed pumps.

James E. Noble.

Toronto, Ont., Can.

⁂

Surging in Discharge Pipes

In reply to J. F. Hurst on the above subject on page 30, July 7, I would suggest that he place an air vent at the highest point of the delivery pipe, and ascertain the number of revolutions required to deliver the water to its destination. If the pumps are engine driven, set a speed enough higher to allow the required speed when the pump is doing its maximum work at full load.

The pump should also be fitted with a gate valve on the outlet side and this valve regulated to suit the amount of water to be passed, it being borne in mind that the power used by a centrifugal pump varies with the weight of water passing through it.

E. R. Pearce.

Rochdale, England.

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*April 7, July 7, 1914.

An Interesting Cylinder Failure

The cylinder explosion described by M. C. Maynard, on page 218, Aug. 11, is interesting, but not entirely surprising.

It is unreasonable to expect a crippled engine to do as much work as when in good condition. The explosion would not have occurred had the engine been slowed down to at least half speed after the intermediate valve was broken; but as the engine was run at full speed on two cylinders, with the torque very uneven, there is little wonder that the part of the piston resting on the shoulder of the rod gave way and fell on the cylinder head, causing it to break away and destroy the entire cylinder. Engines have been run with one cylinder cut out, but they were run at a moderate speed.

Marine engines are subject to great shocks due to the pitching of the ship and counter-currents; and for this reason a great many things which can be done safely with a stationary cannot be done with a marine engine.

SAMUEL L. ROBINSON.

U. S. S. "Connecticut."

As the intermediate cylinder was out of service, more work was thrown on the high- and low-pressure cylinders, which caused a larger demand for steam and lifted the water in the boilers. That fact is clearly proved by the groaning noise in the cylinder, for water will cause that, as I have experienced many times; and Mr. Maynard may rest assured that the accident occurred when the water in the boilers was high, and the result was a large dose of water entering the cylinder, probably accelerated by the ship's pitching.

FELIX HELSMOORTEL.

Saugerties, N. Y.

The accident described on p. 218, Aug. 11, was probably caused by the explosion of the piston from an accumulation of water. It may have been a poor casting, with slag in the iron, and when condensation would take place in the cylinder the water leaked into the hollow core of the piston and was held there by the foundry sand left inside acting as a check valve. When the cylinder warmed up, the water became steam which exploded the piston near the top of the cylinder, at the point of cut-off. This may hasve been the cause of the cylinder head dropping out and the cylinder bursting. The noise probably was the water boiling in the piston.

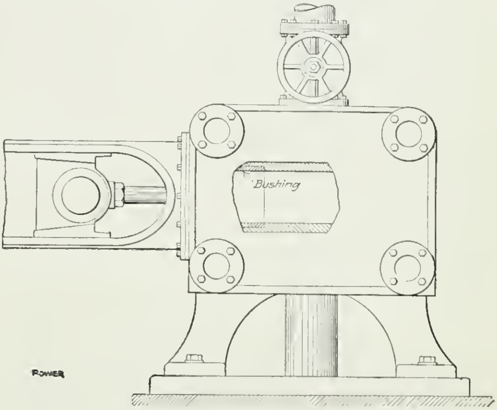
WILLIAM REDFORD.

Jersey City, N. J.

H. B. Boydon's article on page 60, July 14, brings to mind an experience of nine years ago.

The engine was an 18x36x36-in., cross-compound condensing corliss, running at 120 r.p.m. One afternoon the crank end key on the high-pressure side became loose and was thrown out, allowing the piston to strike the cylinder head. The engine was shut down and examined, but no damage could be discovered, so it was put in service again next morning. After having been in operation about two hours, it was noticed that steam was escaping from beneath the high-pressure cylinder. It was again shut down and the lagging removed, when a crack was discovered extending in from the head at the crank end of the cylinder, down under and around to the head again. Two 1-in. bolts were run from head to head and drawn up tight, but they did but little good. We could not obtain another cylinder for six weeks, so it was decided to repair the broken one.

The cylinder was disconnected from the frame and with a portable boring bar it was bored out half-inch larger and six inches beyond the crack. The crack was then made steam tight with iron cement. A cast-iron bushing cast and turned up to the proper size in a local machine shop was forced into the place prepared for it. A light cut was then taken through the cylinder, after which it was replaced and put in service, and I believe it is still in use. The entire repair cost less than $50, while a new cylinder would have cost about $350.



POSITION OF THE BUSHING

I have since had an engine that developed a leak through the lagging of the cylinder, and upon examination a similar crack was found. When the cylinder was opened I discovered a bushing similar to the one described, but I presume the break was not made steam tight before the bushing was put in and the steam worked around it.

LOUIS B. CARL.

Marshfield, Wis.

⁂

Patching Boilers

After reading C. J. Hawkins' inquiry on page 25, July 7, I looked up the rule in Mason's "Arithmetic of the Steam Boiler," which is as follows, but I have some doubts in regard to it.

Taking the efficiency of the joint as though it were a longitudinal joint, then "multiply the length of the seam in inches by the efficiency of the joint and divide by the length in inches measured along a line parallel to the axis of the cylinder."

This is equal to the secant of the angle times the efficiency of the joint.

Now the secant of the angle varies from 1 to ∞ as the angle increases from zero to 90 deg. Evidently one may, by varying the angle, obtain almost any efficiency between the given efficiency and an infinite one. I would be very glad to have this matter explained and also a reliable method given for finding the efficiency of a diagonal joint.

DALE S. MILES.

Independence, Kan.

Lead Boiler Gaskets*

Molds for lead gaskets described in recent issues are good, but unnecessary, as lead gaskets should not be solid. More satisfactory results can be had by using gaskets made of soft lead tubing having an outside diameter of about nine-sixteenths. The pipe should be formed to the desired shape and its ends either burned or soldered together. A number of small holes through the side farthest from the pressure will let the air out as the joint is made up. Lead piping is usually softer than cast lead and readily allows for any rough surfaces and such gaskets may be used a number of times, and are quite suitable for pressures up to 250 lb. for both hand and manhole joints.

E. T. Binns on page 30, July 7, gives good advice for the treatment of soft gaskets, but why use soft gaskets when lead is much more satisfactory?

E. R. Pearce.

Rochdale, England.

[The other contributors have featured remelting and using old lead.—Editor.]

* * *

Figuring Radiation

There are several methods of figuring radiation, beginning at practically guesswork, in allowing a certain number of cubic feet per square feet of radiation and ending with the B.t.u. method in which all the various losses are supposed to be accurately computed and the proper amount of radiation found to offset the losses. But is it possible to accurately figure radiation? I hardly think so and to satisfy myself on this point I made an investigation of the constants used by the different writers. The following table is interesting in showing the wide variation among men who are recognized as authorities in the heating line. Who will say which are the correct constants?

B.T.U. RADIATED PER SQ.FT. PER DEGREE DIFFERENCE IN TEMPERATURE PER HOUR

	Thompson	Gifford	Allen	Carpenter	A Wolff	Hoffman
Brick wall 8"		0.48	0.25	0.37	0.46	0.40
12"	0.265	0.33	0.21	0.32	0.32	0.31
16"	0.210	0.26	0.19	0.28	...	0.26
20"	0.187	0.21	0.16	0.26		0.23
24"	0.167	0.19	0.14	0.24	0.20	0.21
28"	0.152	...	0.13	0.22	0.174	0.19
32"	0.13	...	0.12	0.21	0.15	0.17
36"	0.12	0.12	..	0.20	0.13	...
Single window	1.00	1.07	1.06	0.91 to 0.98	1.09	1.0
Double window	0.50	0.73	0.46	......	0.52	0.60
Single skylight	1.50	1.04	1.16	......	1.12	1.10
Double skylight	0.50	0.61	0.48	......	0.62	0.70
Door	1.00	0.40	0.41	......	0.414	0.4
Stud partition—lath and plaster one side	0.60	0.40	0.60	......		0.60
Stud partition—lath and plaster both sides	0.34	0.31	0.34	......		0.34
Lath and plaster ceiling	0.32	0.40	0.62	......		0.62
Floor	0.10	0.34	0.45	......		0.45
Floor—lath and plaster	0.08	0.27	0.26	......		0.26
Double floor	0.08	.29	0.31			
Double floor—lath and plaster	0.06	0.19	0.18			

The B.t.u. method of figuring radiation is almost universally used where any sort of consistent results are desired, but it is hardly more than an intelligent guess with the present uncertainty as to the real value of radiation constants. Most engineers are inclined to use the higher constants and base their computations on minimum temperatures that are only reached once or twice a season, thus being on the safe side. This often results in more radiation than is actually required and a corresponding increase in cost.

The U. S. Bureau of Standards has made elaborate tests along a great many engineering lines. Penn. State College has recently put into commission a thermal testing plant for standard forms of insulation. Is not the subject of enough importance for one of the above institutions or some other college equipped for testing work to make accurate tests of heat transmission on modern forms of building construction? If this were done the determination of the proper amount of radiation for a building would pass from the land of uncertainty to exactness.

W. L. Durand.

* * *

Air-Compressor Troubles

On starting up a new two-stage air compressor, trouble developed in the high-pressure cylinder. An obstruction in the passages would let only a small amount of water through. After removing the cylinder head, everything seemed clear until a wire was entered in the passage leading to the rear head, which was found to be filled with molder's sand. The opening to the crank end of the cylinder was nearly closed with metal, the core evidently having shifted a little, and cutting this out was a tedious job. After replacing the head, a free flow of water reduced the temperature of the heads.

Oil carbonizing in this cylinder was another source of trouble. Several grades were tried with poor results. Polarine seemed to stop the groaning of the inlet valves, which happened every time the machine was shut down, but this oil also carbonizes a little. I feed it at $1\frac{1}{2}$ drops a minute, but if further diminished the lubricators refuse to work regularly.

This machine is belt driven from a 200-hp. motor and is governed by an unloader on the intake pipe. Its capacity is somewhat greater than the demand for air at present, so it runs light about one-third of the time. I believe this is the cause of my trouble. The oil does not leave the cylinder fast enough when the machine is running light, and is carbonized by the heat, and the demand for air is very irregular. If a smaller amount is used, the valves stick and quiver when running under a load. Perhaps someone can suggest a remedy.

* * *

License Laws and Wages

I do not believe license laws alone will raise the engineer's pay. Ohio has had a license law for several years and it seems to attract men in excess of the demand, thereby keeping the pay low in proportion to the amount of work and study required.

The law provides that an applicant shall make oath that he has been employed at least one year as an engineer, oiler or fireman. I know at least one case where the applicant, after he had failed at the examination, said he had never worked as required by the law, but could get a job any time.

F. D. Crain.

Willshire, Ohio.

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*"Power," Apr. 28, July 7 and 14.

Inquiries of General Interest

Melting Point of Babbitt Metal—What is the temperature of the melting point of ordinary babbitt metal?

R. N. V.

Commercial babbitt metal is made in a variety of proportions of tin, copper, antimony, zinc and often lead, with an average melting point of about 1000 deg. F.

Removing Oil from Boilers—How can boilers be cleaned of oil deposited in them by using feed water returned from a surface condenser?

A. S.

By using a solution of soda ash and water boiled up in the proportion of about 1 lb. per 10 hp., after which the boiler should be blown off and washed out.

Condensing Surface per Kilowatt—What proportion of condensing surface is allowed for operation of large turbo-condensing units?

E. C. S.

In operation of large turbo-condensing units it has been determined by experience that satisfactory results are obtained by employment of 1.6 sq.ft. of condensing tube surface per kilowatt.

Direct-Motion Hoisting Engine—What is the distinctive characteristic of a direct-motion hoisting engine?

F. B. N.

A direct or first-motion hoisting engine is one which has the winding drum mounted on the main or crankshaft of the engine, as distinguished from a second motion hoisting engine which has its winding drum driven by a gear wheel on the engine crankshaft.

Thickness for Babbitting—How can I proceed to get the correct measurements for rebabbitting the bottom shell of a four-part bearing without stripping the engine?

H. R.

Raise the shaft up until it is level, and when in it is also held in proper alignment, the distance the journal is vertically away from the old babbitt added to the vertical thickness of the old babbitt, will give the vertical thickness for the new babbitt at any point so measured.

Inequality of Draft of Connected Boilers—In a battery of eight boilers, if a stack connection of uniform size extends along the rear of all the boilers from No. 1 to No. 8 and is thence connected into a stack of the same diameter and there is an uptake from each boiler to the horizontal stack connection, will boiler No. 1 or No. 8 have the better draft?

M. G.

If the uptake of each boiler has a right-angled connection with the common stack connection and no baffles are employed, then the boiler furthest from the stack will have the better draft.

Connecting Drips of Vacuum-Heating System—In a vacuum-exhaust steam-heating system, how can the drips of mains be connected to the returns so as not to sustain loss of steam or impair vacuum in the returns?

J. H. N.

A main drip should be sealed by running it so as to form a deep trap before discharging to the returns. The highest point of the trap so formed should be at least 20 to 30 in. lower than the connection to the steam main, and the deeper the trap the higher the vacuum may be carried before siphoning will take place.

Horsepower of Alternating-Current Motor—How is the horsepower found on a three-phase a.c. motor when voltage and amperage are given?

E. F. R.

The power of a three-phase motor is given by the formula

$$\text{KW} = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor}}{1000}$$

This applies to the current in any phase, and the voltage is that measured across any two of the live wires. As one horsepower is equivalent to 0.746 kilowatt, the horsepower of the motor would be the kilowatts found by the formula divided by 0.746.

Connections for Exhaust Steam Heating—Should heating coils and radiators which are supplied with exhaust steam have single or double connections?

W. N. J.

When the supply of exhaust steam is continuous and practically uniform in pressure and operated as a closed gravity-return system, either single or double pipe connections may be employed as in ordinary low-pressure steam-heating, but when the returns are discharged as a vacuum system or for blowing out the heating system of air and water to quicken the circulation, the coils and radiators should be provided with separate steam and return connections.

Size of Motor for Centrifugal Pump—A centrifugal pump has a rated capacity of 250 gal. per min. pumping against a total head of 120 ft. with an efficiency of 53 per cent. What size of motor should be selected to drive the pump?

S. B. R.

Pumping 260 gal. per min. against a total head of 120 ft. with an efficiency of 52 per cent. would require:

$$\frac{260 \times 8\frac{1}{3} \times 120}{0.52 \times 33{,}000} = 15.12 \text{ hp.,}$$

and allowing 10 per cent. loss in transmission the power of the motor should be

$$\frac{15.12}{100 - 10} = 16.8 \text{ hp.}$$

Size of Pump for Vacuum-Heating System—What is the formula for size of pump for a vacuum steam-heating system?

F. P.

A formula for the approximate size of air cylinder for a vacuum pump of a vacuum steam-heating system is

$$d^2 \times L = \frac{S}{35}$$

in which

d = Diameter of air cylinder in inches;
L = Length of stroke in inches; and
S = Number of square feet of radiating surface to be drained.

Temperature Difference of Steam and Discharged Condensing Water—What is the temperature difference between the steam and condensing water as discharged from a condenser?

W. J.

In good practice, there is a difference of 10 deg. to 15 deg. F. between the temperature of the outgoing cooling water and temperature of the incoming steam, depending on the type of condenser and volumetric ratio of water to steam. A good surface condensing plant with dry-air pump should operate at 28 in. vacuum with a temperature difference of 15 deg. F., but there are many plants which are operated with a difference of 25 to 40 deg. Although it may be possible for a good barometric or centrifugal jet condenser to operate with less temperature difference than 10 to 15 deg., commercial practice rarely concedes better results

Pump Capacity—How much water per hour will a duplex steam pump handle having a 6-in. steam cylinder, 4-in. water cylinder and 6-in. stroke, when making 75 r.p.m.?

F. C. L.

The cross-sectional area of the water cylinder, neglecting the area of the rod, is

$$4 \times 4 \times 0.7854 = 12.566 \text{ sq.in.}$$

The displacement for one 6-in. stroke would be

$$12.566 \times 6 = 75.396 \text{ cu.in.}$$

and for 150 (i.e., 2 × 75 r.p.m.) strokes and two cylinders (the pump being duplex) would be

$$75.396 \times 150 \times 2 = 22{,}618.8 \text{ cu.in. per min.}$$

or

$$\frac{22{,}618.8}{231} = 97.917 \text{ gal. per min.}$$

or

$$97.917 \times 60 = 5875.02 \text{ gal. per hr.}$$

These figures do not take slippage into account.

Engineers' Study Course

Elementary Mechanics—XXV

Last Lesson's Answers

111. Since there are four threads per inch, the pitch is $\frac{1}{4}$ in. Let Fig. 75 represent the development of the thread. The base of the plane is the circumference of the screw; the altitude is the pitch; and the hypotenuse AC is the length of the thread. The motion of the jack is equivalent to motion on the inclined plane AC.

By construction

$$tan\ a = \frac{BC}{AB} = \frac{\frac{1}{4}}{6.28} = \frac{1}{25.12} = 0.04 \quad \text{(approximately)}$$

From a table of tangents the value of the angle a is found to be 2 deg. 20 min. From equation (66) the efficiency of the inclined plane is $E = \frac{1 - f\ tan\ a}{1 + f\ cot\ a}$

From the conditions of the problem the value of f is 0.14; the $tan\ a = 0.04$ and the $cot\ a = 25$. Substituting these values in equation 66, the efficiency of the jack is found thus:

$$E = \frac{1 - 0.14 \times 0.04}{1 + 0.14 \times 25} = \frac{0.9944}{1 + 3.5} = 0.22 \text{ or } 22 \text{ per cent.}$$

112. In one revolution of the lever the point A will move a distance equal to 2 × 3.1416 × 2 or 12.56 ft. The force exerted by the man is 40 lb. and the work done per revolution of the jack is 40 × 12.56, or 502 ft.-lb., which quantity represents the *input*.

Let W equal the weight raised. In one revolution of the jack this weight will move a vertical distance of ¼ in. or the pitch of the screw. Hence the *output* = $W \times \frac{1}{4} = W/4$ in.-lb., or $W/48$ ft.-lb. By equation 53 $efficiency = \frac{output}{input}$. In problem 111 the efficiency of the jack was found to be 22 per cent. Substituting the values of the efficiency, input, and the output in the above equation there results,

$$0.22 = \frac{W/48}{502} \text{ or } W = 0.22 \times 502 \times 48 = 5300\ lb.$$

113. The effective force moving the car down the plane is the force of gravity minus the force of friction. From the discussion of the inclined plane the force of gravity, G is $W \times sin\ a$. In this problem $sin\ a = 1/18$, hence

$$G = W\ sin\ a = 2000 \times 1/18 = 111\ lb.$$

As the force of friction F is assumed to be 20 lb., the effective moving force is

$$(G - F) = (111 - 20) = 91\ lb.$$

The acceleration a may be found from equation 49, where

$$F = \frac{W}{g} \times a, \text{ or}$$

$$a = \frac{F \times g}{W} = \frac{91 \times 32.16}{2000} = 1.46\ ft.\ per\ sec.$$

114. Use the equation (32) $V^2 = 2\ aS$. Here a = 1.46 ft. per sec., and S = 500 ft.; therefore,

$$V^2 = 2 \times 1.46 \times 500 = 1460, \text{ or}$$

$$V = \sqrt{1460} = 38.2\ ft.\ per\ sec.$$

115. The car, including the load, weighs 2000 lb., and its velocity at the foot of the plane is 38.2 ft. per sec. The kinetic energy in the car, due to its velocity, is $\frac{WV^2}{2\ g}$, or $\frac{2000 \times 38.2 \times 38.2}{2 \times 32.16} = 45{,}374\ ft.\text{-}lb.$

This energy must be absorbed before the car will come to rest. When the car is running on the level the only resistance to be overcome is the force of friction which, in this case, is 20 lb. The work done in overcoming this resistance through a given distance of S ft. is $F \times S$ ft.-lb., which must equal the energy in the car, or $F \times S = \frac{W \times V^2}{2\ g}$, where F = 20 lb., and $\frac{WV^2}{2\ g}$ = 45,374 ft.-lb. Hence, $S = \frac{WV^2}{2\ g\ F} = \frac{45{,}374}{20} = 2268$ ft.

Projectiles

In the previous lessons the motion of a body was limited to straight lines. There are cases where the path of the body may be a curve. If an object be projected vertically upward it will rise in a straight line to a certain height and then descend in the same straight line. If, however, the object be projected at an angle to the vertical the path described will be a curve, the form of which will be determined. In the following discussion the resistance of the air will be neglected, as an attempt to correct for it would require a knowledge of mathematics beyond the scope of this work. The acceleration due to gravity will be considered as uniform.

When an object is projected into the air, the angle that the direction in which it is projected makes with the horizontal is called the *angle of projection*. The path the object describes is called its *trajectory*. The distance from the point of projection to the point where the object again passes the plane of projection is called the *range*. The time that elapses before the object meets the plane of projection is called the *time of flight*.

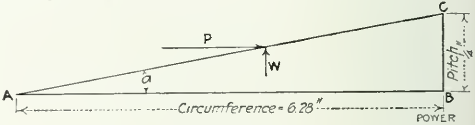

Fig. 75.

As stated in Newton's second law of motion, a body would continue to move in a straight line forever if it were not for other external forces which are brought to bear on the body. The instant a bullet leaves a rifle gravity acts and tends to change the path of the bullet.

Projectiles may be divided into several classes, depending upon the angle of projection.

Class I. Bodies projected vertically upward. (This class has been discussed in lessons XVIII and XIX.)

Class II. Bodies projected horizontally from a point at some elevation above a given reference plane.

Class III. Bodies projected at an angle to the horizontal.

In Fig. 76, assume an object to be projected horizontally from the point C with a velocity of V ft. per sec. Let H = the elevation, in feet, of the point C above the horizontal plane AB. It is desired to find at what point B the object will reach the ground and also the time of flight from the point C to the point B.

At the end of the first second the projectile would be at the point E, a distance of V ft. from the point C, if it were not for gravity, which in the same second causes the projectile to fall a distance of $\frac{1}{2}\,g$ ft. The net result is that at the end of the first second the body is not at the point E, but at a point M, 16 ft. below E. Likewise at the end of the second second the body would be at the point F, due to its initial velocity, but during these two seconds gravity causes it to fall a distance of

$$\tfrac{1}{2}\,gT^2 = \tfrac{1}{2} \times 32.16 \times 2^2 = 64 \text{ ft.}$$

so that the projectile is at the point N, which is located 64 ft. below F. At the end of the third second the projectile is at the point O, which is $4\frac{1}{2}\,g$, or 144 ft. below G. Hence to plot the true path of the projectile, the following method may be used:

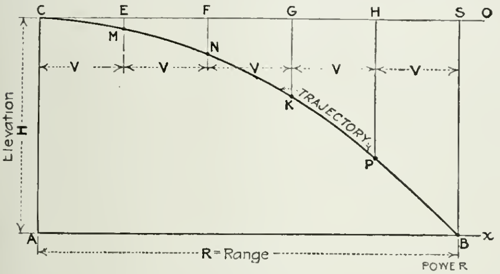

FIG. 76.

Lay off the vertical distance H (Fig. 74) to a definite scale; that is, one inch of height represents a fixed number of feet. Draw the horizontal reference line AX, and through the point C draw the line CO parallel to the line AX. On the line CO locate the points E, F, G, etc., so that the distance between any two consecutive points is equal to the initial velocity of the projectile in feet per second. Through the points E, F, G, etc., draw vertical lines, and on these lines lay off distances equal to the space through which a body would fall due to gravity in the given number of seconds. Thus at the end of the first second the body would have fallen a distance of 16 ft., and so the distance EM is made 16 ft. to scale. The distance FN is 64 ft., GK is 144, etc. A smooth curve drawn through the points C, M, N, K, B, will give the trajectory of the projectile.

The time of flight will be the same as if the projectile had been let fall from the point C and has nothing to do with the initial velocity of the projectile, but is entirely dependent upon the vertical distance AC. The simultaneous action of the velocity V and the action of gravity produce the same effect as though these forces acted independently of one another, that is the projectile may be considered as first moving from the point C to the point S with a velocity of V ft. per sec., and then falling, due to gravity, from the point S to the point B.

The time that it takes for the projectile to fall the vertical distance AC or H ft. may be found from equation (42) where $H = \frac{1}{2}\,gT^2_1$; and when the time is known the horizontal distance AB or the range is found from the equation $S = V \times T_1$. Therefore, let T_1 = the whole time of flight; H = the vertical distance from the plane AB to the point of projection; V = the velocity of projection in feet per sec.; and R = the horizontal range or the distance AB.

Then
$$T_1 = \sqrt{\frac{2\,H}{g}} \tag{67}$$
and
$$R = V \times T_1 \tag{68}$$
or
$$R = V\sqrt{\frac{2\,H}{g}} \tag{69}$$

The above formulas apply only to problems coming under Class II.

STUDY QUESTIONS

116. A horizontal belt conveyor is located 100 ft. above the ground. Coal leaves the conveyor with a horizontal velocity of 20 ft. per sec. How long after the coal leaves the conveyor will it strike the ground?

117. Find the horizontal distance from the conveyor to the point where the coal strikes the ground.

118. Find the magnitude and direction of the velocity of the coal when it strikes the ground.

119. In Fig. 14, lesson IV, the governor ball B is 15 in. from the center of the spindle when revolving at 100 r.p.m., and is 15 ft. above the floor line. If the ball were to suddenly break loose from the spindle, how far would it travel before striking the ground?

120. What would be the time of flight?

Engine Throttle Valves

In the account of the flywheel explosion at the Union Brewing Co.'s plant, page 115, July 21, the picture shows that the throttle valve had a long stem which brings the wheel out over the valve-gear and in line with the flywheel. Engine builders are not giving the position of the throttle valve the attention that it should have from the viewpoint of the safety of the engineer.

All engines of even moderate size should be equipped with an engine stop which will close the throttle in an emergency, but they are not always provided and it is often difficult to get the company to incur the expense. When the valve with a long stem is used there should be a bearing for the stem near the handwheel to prevent the side strain causing the stem to become sprung.

Another trouble sometimes found is that the packing gland is drawn up too tight. This should not be done. The packing should be renewed often enough to prevent it from becoming hard. Some engineers on opening the throttle or other valve, turn it wide open, and wedge the stem tight. When left in this position the valve is hard to start when it is to be closed. A valve should be opened wide, then turned back part of a turn to free it.

A handwheel of small diameter with a polished rim should not be used. In the case referred to if the throttle had been arranged as suggested, it is likely the engineer could have closed it quickly, preventing the accident.

⁂

Ice Making in Ireland—In the city of Cork there is, it is reported, only one ice plant, which supplies all the ice for domestic and public use for the entire southern part of the island. The output is only six tons per day. There are a few individual firms operating refrigerating machinery for their own use.

Fireman Fatally Scalded

On July 30, at 7:30 in the morning, Peter McArdle, a fireman, was scalded to death in the plant of the Mallers Building, 237 South Market St., Chicago. The plant is equipped with two Scotch boilers which operate on pressures of from 60 to 100 lb., the safety valves being set for 105 lb. The blowoff pipes are carried out at the sides of the boilers and by means of a tee connection discharge through a common pipe running to a cast-iron blowoff tank at the rear of the boilers. The room here is restricted and the ground level is four steps below the basement floor. To get at the blowoff valves it is necessary to enter a narrow space between the two boilers.

The tank was 23 years old and showed signs of serious corrosion. On this account it had been the custom to blow down at a pressure not exceeding 20 lb., but on the fatal morning full pressure was on the one boiler which was in operation when the fireman started to blow it down. Just as he opened the valve, the bottom blew off of the tank, forcing the rest of it upward. Naturally, the piping was carried along with it and the latter in turn pulled the tee away from the blowoff pipes. The hot water and steam rushing out overpowered the fireman and before help could reach him he was fatally scalded.

⁂

Effect of Different Methods of Lubrication on the Moving Parts of Reciprocating Engines*

Experiments have been made to determine the impact on the bearings of reciprocating engines with different methods of lubrication with the idea of reducing noise and shock. The engine used was a single-cylinder, double-acting center-crank type with Corliss valve gear, 7-in. cylinder diameter and 17½-in. stroke, the speed varying from 50 to 125 r.p.m. The force of impact was measured by an inertia apparatus fixed to the connecting rod and by an electric circuit. Indicator diagrams were taken with a drum motion proportional to the time. With this measuring apparatus the force of impact, or the greatest retardation during the change of pressure, was obtained, also the point of the crank circle where the change of pressure took place. Different tests were made for several cutoffs, several lengths of compression, under varying speed, for different kinds of lubrication and for different clearances in the crank and crosshead bearings. Lubrication was applied in three different ways:

1. With sight feed oilers—drop lubrication.
2. Forced lubrication under a head of 12 in.—flood lubrication.
3. Forced lubrication with a head of 15 ft.—pressure lubrication.

Results of the tests are shown in the two diagrams. Fig. 1 gives the force of impact plotted against the velocity of impact. The full lines relate to the crankpin, the broken lines to the crosshead pin. The speed of the engine is given by the numbers along the curves. The most striking feature of this diagram is the great advantage of continuous lubrication over intermittent lubrication. The improvement of curves C and E over curve A (for the crankpin), or of curves D and F over curve B (for the crosshead pin), is so striking that it is unnecessary to make any further comment.

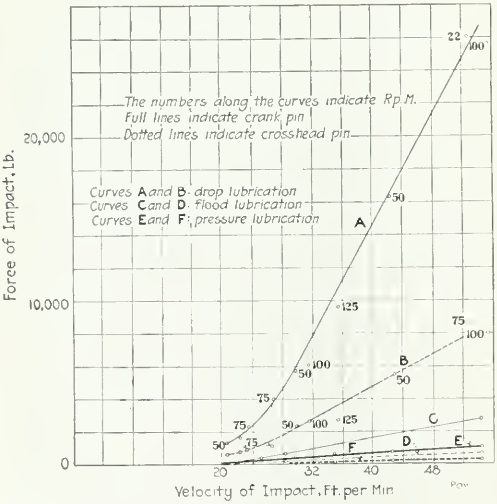

FIG. 1. VELOCITY VS. FORCE OF IMPACT

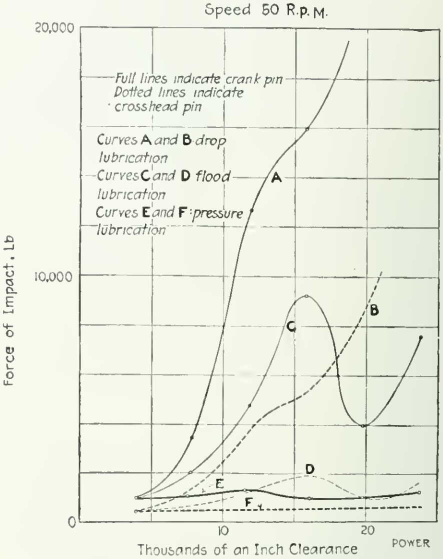

FIG. 2. CLEARANCE VS. FORCE OF IMPACT

Fig. 2 shows the influence of lubrication on the force of impact for different clearances between the pin and bearing. The result is the same—great advantage of continuous (flood or pressure) lubrication over intermittent (sight feed or drop) lubrication.

It may be interesting to add the conclusions the author draws from his experiments. He says:

> 1. The point of the crank circle in which the change of pressure takes place has no influence on its magnitude, as shocks occurring at dead center may be just as light or heavy as shocks before or after the dead center.
>
> 2. The speed of the engine influences the amount of change in pressure only in combination with the shape of the indicator diagram. (Compression line and inertia line.)
>
> 3. Lubrication has the greatest influence. Insufficient lubrication means heavy shocks under all circumstances. High oil pressure shows some improvement over low oil pressure, but not as much as flood lubrication shows it over drop (sight feed) lubrication.

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*Translated and abstracted by W. Turnwald from a report by Dr. Ing. Hans Polster in "Zeitschrift des Vereines Deutscher Ingenieure."

⁂

The Illuminating Engineering Society will hold its annual convention in Cleveland, Ohio, Sept. 21 to 25, inclusive. A most interesting list of papers will be read and discussed.

⁂

A New High-Power Water Pump, with a capacity of 30,000,000 gal. a day, built by the Allis-Chalmers Co., was recently installed under the supervision of Wayne W. Mackey, erecting engineer of the company, at the Broadway pumping station of the Toledo Water Works, Toledo, Ohio. It has the distinction of being one of the greatest pumping engines of its class ever constructed, and cost $83,000. The pump is of vertical triple-expansion design, and the cost of operation is estimated as one-sixth of the cost of maintenance of the original 5,000,000-gal pumps formerly used. It will increase the water providing capacity of the Broadway station to 72,000,000 gal. daily. Toledo's normal daily supply is less than half of this amount. All of the cylinders, heaters and steam lines connected with this pump are insulated with coverings, furnished by the H. W. Johns-Manville Co.

Australian Meeting British Association for the Advancement of Science

The Association is this year repeating its custom, initiated in 1884, of holding occasional meetings in the British Colonies. The first meeting of this kind was held in Montreal in 1884; Toronto was visited in 1897, Winnipeg in 1909; South Africa in 1905, and Australia was selected for 1914. Two large parties of delegates left the home country for Australia at the end of June and early in July, and these were reinforced when they arrived, by the local Australian members, and by others who joined as associates for the Australian meeting only. The meetings were held during July and Aug. in Perth, Adelaide, Melbourne, Sydney and Brisbane, the five state capitals.

PRESIDENTIAL ADDRESS

Professor Coker, in his address to the Engineering Section, dealt with "Stress Distribution in Materials." Different methods for investigating stress distribution in materials were discussed, especially the optical method of studying (by aid of the polariscope), the strains in transparent models of the machine or structure. In the majority of cases the simplest and the most direct method is the experimental study of a model, from which are obtained the data required for calculating effects on a full-sized structure; hence the laws of similarity have received close scrutiny. The optical effects for any given load, are independent of the thickness of the material, and depend upon the stress difference, so that color effects are obtained which may be regarded as pictures of shear stress throughout the model. Modern researches on ductile materials like structural steel, indicate that such materials fail at some limiting value of shearing stress, and since the places where these limiting values are reached in the model are visible to the eye, the weak places in the design of a structure can be ascertained, and a faulty design corrected, by purely experimental means.

As applied to boiler design and construction, Professor Coker was of the opinion that ample scope for further inquiry was here afforded; but before more exact knowledge can be gained of the conditions of stress in a complicated riveted joint, it appears necessary to examine thoroughly the simple cases.

"Mr. Scoble and I," said he, "have examined the case of the load applied by one rivet to a plate with various amounts of overlap, and the stresses around the rivet holes have been measured with fair accuracy. The stress at the boundary of a small cylindrical hole in a plate has been found almost three times the stress in the full plate and the effects of holes comparable with the width of the tension member, have also been examined in some detail. In the case of a rivet just filling the hole and exerting no tangential effect at the boundary, there is a lessened tension stress across the minimum section at the boundary hole, accompanied by a marked radial tension. These effects have been recently confirmed in a mathematical discussion by Suyehiro. Other cases give satisfactory agreement with calculations, and we may therefore feel some confidence that experimental investigation will prove useful in some of the very complicated cases arising out of engineering practice, where analysis is difficult if not impossible."

THE BEHAVIOR OF METALS UNDER STRAIN

The same subject was dealt with by Dr. Walter Rosenhain, who stated that for a rational understanding of the behavior of metals under strain, the truly crystalline character of all metals and alloys in their normal (cast or annealed) state, was of fundamental importance. The more detailed and difficult questions connected with the deformation and fracture of metals which have received increasing attention recently, were next considered, including such phenomena as "fatigue," testing by, and failure under, shock or repeated impact, and the phenomena of semi-plasticity and elastic recovery. The behavior of metals at high temperatures was also discussed, and the explanation of these phenomena afforded by the modern development of the theory of an amorphous phase in metals, as originated by Beilby and extended by the author and his collaborators, was summarized.

An interesting paper on "The Economics of Liquid Fuel for Marine Purposes," was read by Professor Kirkaldy, and although this related chiefly to the use of fuel for steamships, some of the points discussed in the paper, cover equally well the supplies of liquid fuel for power purposes, on land. Discussing the advantages of oil as compared with coal for ships, he submitted the following tabulation:

WHERE USED AS FUEL FOR STEAM BOILERS

(1) One ton of oil will do the work of 1½ tons of coal.

(2) The bunker space is greatly reduced because: Less fuel need be carried; the oil can be pumped into any out of the way space in the ship; and oil can be carried in the ballast tanks.

(3) Economy in transporting, handling, storing and stowing.

(4) Less labor is required, because the number of firemen can be reduced by one-third; no trimmers are required; food costs are also reduced by one-third; less accommodation is required for the boiler-room staff. The saving in wages, food and cost of fuel in a recent trial of oil against coal, tried on the same vessel, showed an advantage in favor of oil of $170 in one day's steaming, on a ship of 3800 tons.

WITH INTERNAL-COMBUSTION ENGINES

(1) One ton of oil will do the work of four tons used for heating boilers.

(2) There is considerable reduction of bunker space over oil-fired boilers and steam engines, and a much greater saving of space over coal-fired boilers and steam engines.

(3) There is the economy in handling, transporting, storing and stowing already noted, and less labor is required. Here there is an economy over boilers and steam engines, as neither firemen nor trimmers are required.

(4) The engines occupy much less space than the steam boilers and engines.

As regards the world's resources of liquid fuel, the author stated that these are far greater than were at one time recognized and include oil in the fluid state and various shales, coal, etc., from which oil can be distilled.

As regards oil in the liquid or fluid state of areas already supplying oil, there is eastern Europe, and apparently a vast workable area running thence throughout Asia, to the Pacific. The known resources of North and South America are great, and in Canada, the West Indies and in many parts of South America, there is promise of equally rich supplies yet to be tapped.

The various shale areas have hitherto scarcely been worked. Scotland is rich in shales, and there are rich areas in Australia, New Zealand and South Africa. So far as coal is concerned, to utilize it in this way would result in economizing coal resources, and much that is now wasted would be utilized. Some distilled oil contains impurities, but this drawback must sooner or later be overcome.

DISTRIBUTION OF PHOSPHORUS IN STEEL

A paper by Doctor Rosenhain, of interest to boiler-makers, dealt with the distribution of phosphorus in steel. The author stated that the injurious influence of phosphorus is generally recognized, so much so that for a large class of important steel articles, it is usual to specify that the phosphorus content shall not exceed 0.035 per cent. If phosphorus were uniformly distributed throughout steel, it would be difficult to believe that less than four parts in ten thousand could be seriously injurious. Observations of ordinary commercial steels, however, serve to show that phosphorus is not uniformly distributed. This matter has been studied by J. E. Stead, by the method of heat-tinting, which differentiates between those parts of a polished steel surface rich in phosphorus, and those free from it, by the difference in the rate of oxidation. The banded distribution of the phosphorus thus reproduces as bands of different depths of tinting, on the surface, after exposure to heat.

More recently, the author and J. L. Haughton, at the National Physical Laboratory, worked out a method of tracing the phosphorus distribution in steel, by means of a new reagent. This is a solution of ferric chloride, rendered acid by hydrochloric acid, and containing in solution small quantities of the chlorides of copper and tin. When a steel surface is exposed to this reagent, electro-chemical replacement occurs, a small quantity of iron passes into solution, and a corresponding amount of copper is deposited as a thin film on the surface of the steel. In an ideally pure steel this deposit would be uniform over the entire area of the ferrite constituent, but in a phosphoric steel the copper film is deposited first on those ferrite regions which are most nearly pure, those regions richest in phosphorus being left unaffected for a long time.

TESTING OF MATERIALS BY MICROPHOTOGRAPHY

In this paper Professor Dalby stated that the practice of showing the structure of metals by means of microphotography has steadily developed during the last few years. He recently applied a photographic method of obtaining a record of the relation between the load and extension of metals, right up to the breaking point. The diagrams taken in this way show clearly the peculiarities of the metals at their yield points, and also the actual load on the specimen, at the moment of fracture.

COMMITTEE REPORTS

Two important reports were presented, one dealing with "Gaseous Explosions" and the other with "Stress Distribution." The former was the seventh report of the scientific committee, which was first appointed in 1907, for the study and investigation of the explosion phenomena in internal-combustion engines. The report presented this year contains a summary of the contents of the previous six reports.

The first part is devoted mainly to the subject of the specific heats of gases at high temperatures. The constant-pressure experiments of Wiedemann, Regnault, Holborn and Henning are analyzed and discussed, and a curve is given showing the energy of CO_2, steam and air, in terms of temperature. The experiments of Dugald Clerk are described, and the results obtained compared with the constant-pressure experiments mentioned. The closed vessel experiments of Mallard, Le Chatelier and Langen are analyzed and the results plotted and discussed.

Dr. Watson's researches on the efficiency of a gasoline engine are included. In these, simultaneous measurements were made of the quantities of air, and gasoline taken into the engine, and of the chemical composition of the exhaust gas. The point brought out was that the ratio of hydrogen to carbon in the exhaust was greater than the ratio of hydrogen to carbon in the gasoline used. Additional evidence of this discrepancy is furnished by some experiments of Professor Hopkinson.

Radiation from gases is next discussed and a brief general history of the subject is given, together with a record of the experiments of Professor Hopkinson and of Professor Callendar. The direct effect of radiation on the efficiency of internal-combustion motors, the amount of radiation from flames, and the molecular theory of radiation from gases, as well as the question of the transparency of flames to their own radiation are reviewed. There is an appendix on the radiation of flames by Professor Callendar, giving some account of experiments made with a Meker burner; a second appendix on the radiation in a gaseous explosion by Professor Hopkinson; and a third appendix which contains abstracts from various papers relating to the application of heat radiation, from luminous flames, to Siemens' regenerating furnaces.

The fifth section of the report continues the discussion of the effect of radiation, and is devoted mainly to the consideration of the factors which determine the heat-flow from the gas to the walls of the cylinder. The remarkable effect of turbulence on the rate of combustion is here mentioned. Particulars of Dugald Clerk's experiments are given, and these definitely establish the fact that but for turbulence the speed at which modern internal-combustion engines are run would be impossible. Professor Hopkinson's experiments, in which a fan was placed inside a closed vessel, and the rates of combustion observed with the fan at rest and in motion, are recorded, and confirm Dr. Clerk's results.

The second report on "Stress Distribution in Engineering Materials" stated that the reports presented at the Birmingham meeting of the Association led the committee to the view that the coördination of the results of various researches was rendered difficult by the diversity of the materials used in the tests. It was therefore thought desirable to obtain complete and systematic data with regard to three definite materials, namely, a mild-steel, a hard-steel, and a steel-alloy. Accordingly a stock of three tons standard steel has been obtained for the committee; this consists of dead mild-steel (carbon 0.12 per cent.), axle-steel (carbon 0.03 per cent.) and nickel-steel.

Some of the steel has already been sent to various members of the committee, and in due course full information will be available with regard to the behavior of the three materials, under a large number of different tests.

Information with regard to the manufacture of the standard steels is given in an appendix.

A number of members of the committee have, during the past year, been engaged in investigating subjects dealt with in last year's reports, but in most cases the experimental work is not yet completed. The subjects under investigation are as follows:

Professor Coker and Mr. Scoble, shear tests; Mr. Cook, tests of the physical constants of the standard steels; Messrs. Cook and Robertson, further work on the strength of thick cylinders; Mr. Fulton, alternating stress at low frequencies; Mr. Guest and Professor Lea, combined stresses; Mr. Mason, repeated combined stresses; Mr. Scoble, repeated combined stresses; Dr. Stanton, repeated shear tests.

American Boiler Manufacturers' Association

The twenty-sixth annual convention of the American Boiler Manufacturers' Association was held at the Waldorf-Astoria Hotel, New York City, Sept. 1 to 4, inclusive. The question of the standardization of steam-boiler specifications received considerable attention, and it is hoped that some progress will be made toward harmonizing the variations existing at present between the laws of the different states.

The opening session took place Tuesday morning at 10 a.m. In the absence of the president, Col. E. D. Meier, Capt. T. M. Rees presided. Addresses of welcome by Hon. Henry Bruere, city chamberlain, and Charles R. Lamb, a director of the Merchants' Association, of New York, were made and responded to by W. H. S. Bateman.

Reports of executive and membership committees and appointment of committees on place of next meeting, nominations and auditing, etc., occupied the meeting Tuesday afternoon, and in the evening a reception and dance was held in the Waldorf Astoria.

Wednesday forenoon and afternoon were given to the reports of the committee on uniform specifications and the committee on uniform boiler laws. Thursday the reports were read of committees on uniform system of cost keeping, place of next meeting, auditing and nominations, and discussion of topical questions took place. The banquet was held in the evening.

On Friday there was the executive meeting in the forenoon as the official ending of the convention, and the afternoon and evening were spent at Coney Island. The complete report of the meeting will appear in the next issue.

Recent Court Decisions

Digested by A. L. H. STREET

Right to Enjoin Flooding of Land—In a recently announced decision the New York Court of Appeals recognizes the principle that, as a matter of strict legal right, an owner of land bordering a stream is entitled to have the natural fall of the stream left uninterfered with by any person who has not legally acquired a right of flowage, but decides that one who buys land, knowing that an apparently worthless part of the property is submerged in the maintenance of a nearby dam, is not entitled to maintain a suit to enjoin the owner of the dam from continuing to flood the lands, especially where the dam has been constructed at great expense and is used in supplying electricity for public and private use. (McCann vs. Chasm Power Co., 105 "Northeastern Reporter," 416.)

Right to Maintain Dam—A right to maintain a dam in a stream to develop power, acquired by long continued use without objection from property owners affected, does not authorize increase of the height of the dam, according to the Iowa Supreme Court's opinion handed down in the case of Iowa Power Co. vs. Hoover, 147 "Northwestern Reporter, 858. In the same case it is decided that legislative grant of permission to maintain a dam does not exempt liability for injury to lands along the stream resulting from maintenance of the dam.

Power Plant at Mouth of Mine

At Floodwood, Ohio, in the Hocking Valley, a power plant is now under erection which is to generate current at the mouth of a mine and distribute it to the surrounding territory. There are about 70 mines i nthis district, all of which are possible customers for the station, and within a radius of 50 miles there are numerous towns of good size which offer a promising field. Columbus is only 60 miles away, and Cincinnati 150. To run the transmission to either city is a possibility of the future.

The plant is located at the junction of Monday Creek, with the Hocking River on one of the flats between the numerous hills along the river bank. A 1000-acre bituminous coal mine adjoins the plant, and the fuel is to be taken from a side hill at an expense which is estimated at 70c. per ton. The coal is easy to get at, and as it will be removed continuously throughout the year, it is thought that the cost will be less than for coal mined for commercial use. The water supply is abundant and good, as there are no mines farther up the river to instill sulphur and other impurities into the stream.

In building, the unit plan has been adopted. Additions will be added from time to time as conditions warrant. The initial installation consists of three 1800-kw. condensing turbines driving three-phase, alternating-current generators. These machines have already been placed on their foundations, but the water-tube boiler equipment and the coal-handling machinery are not yet on the grounds.

Two or three syndicates have an interest in the development, but at the present writing the operating company has not been incorporated. It is planned to have the plant in operation some time in November.

ENGINEERING AFFAIRS

Public Service—To provide for a committee on public relations, to have charge of those activities which include service to the public other than that rendered directly to individual members and the profession as a whole, the public relations committee of the American Society of Mechanical Engineers announces that public service has been designated by the committee on meetings as the central theme for the annual meeting in December 1914. At the request of the committee, the public relations committee has taken charge of the program for Thursday, Dec. 3, and it will be devoted to papers on municipal engineering and related matters. The session will be opened by John Purroy Mitchel, mayor of the city of New York.

Great Exposition (Grosse Ausstellung) Düsseldorf, Germany, in 1915, with the coöperation of the German Museum, Munich, has been instituted under the auspices of the city of Düsseldorf and the Artists, and is designed to represent what human mind and energy have perfected or inaugurated during the last hundred years. It will show the gradual development of science and industry during this period; foremost of all, however, it will illustrate the present high standard of industry and craft. The juxtaposition of the past and present will give the visitor a clear view of the progress which unwearied toil and far-reaching investigation have brought about. The exhibition which, for the first time, is open to foreign firms is backed by a fund of Mks. 5,000,000 guaranteeing its financial success. Prominent persons of wide experience have given their energies to the service of the udertaking, which will be carried through in the dignified way, traditional to the exhibition town of Düsseldorf.

The ten groups to be represented are Art and Science, House and Home, Industry and Trade, Woman, Army and Navy, Traffic, Sport and Hunting, Agriculture and Horticulture, Legislation and Reform. Group 3 contains the subsections of power, light and mechanical labor, engineering, mining, salt works, iron, metals, the trade in manufactured goods, the textile industry, food and beverages, labor, trade, craft, along with allied industries.

OBITUARY

ALBERT B. FRANKLIN

On Saturday morning, Aug. 29, Albert B. Franklin, a well known heating and ventilating engineer, died at his home in Melrose, Mass. He was born in Roxbury, Jan. 28, 1852, the son of Benjamin and Clara (Stowell) Franklin, and descendants from Revolutionary stock.

He prepared for college at the Roxbury Latin school, but owing to illness was unable to enter college. Mr. Franklin entered the employment of J. J. Walworth & Co., of Boston, in 1870 to learn the trade of a steamfitter, and continued with that firm until November, 1878, when he left and went into business for himself.

This firm has carried out contracts for heating and ventilating some of the largest public and business buildings in New England, including the Boston State House, the Melrose High School and other school buildings of Melrose, and the Memorial Hall and Melrose Hospital.

Mr. Franklin was a generous giver of his time and his money, and possessed a vigorous intellect.

He was a member of the Middlesex Club, Congregational Club, the Men's Club of the First Congregational Church, Bethlehem Council, the Royal Arcanum, Knights of Pythias, and Garfield Lodge A. O. U. W.

In 1902 he joined the American Society of Heating and Ventilating Engineers; 1905-1908 he was on board of governors; 1911, second vice-president; 1913, first vice-president, and a member of the Massachusetts Chapter and of the board of governors, 1913-1914.

He was married Sept. 30, 1874, to Helen Frances Jenness, who survives him, together with six children. The business will be continued by Mr. Franklin's sons Laurence and Ralph.

THEODORE GERARD MEIER

Theodore G. Meier, treasurer of the Heine Safety Boiler Co., died on Aug. 16. Mr. Meier was born in Bremen, Germany, Mar. 17, 1836. When he was a year old his parents decided to go to America. His father, Adolphus Meier, selected St. Louis as promising to become a great center of business, and sailed from Bremen to New Orleans, with his little family, in a small brig, which arrived safely after a tempestuous voyage of 113 days. From there a steamboat took them to St. Louis in eleven days. Here T. G. Meier grew up with such schooling as the little town then afforded.

In 1842 and in 1849 the family visited Bremen, where Mr. Meier got the advantage of better schooling during his stay of two years, graduating from the High School of Commerce in 1851. He then attended the St. Louis University as a general student. Later he entered his father's business (hardware and cutlery) as a clerk, and for further practical training, entered the employ of Butler, Keith & Hill, Boston, Mass., for two years, re-entering his father's business, to which meanwhile had been added a small cotton factory. He rose from clerk to partner, and in 1862 took entire charge of the cotton factory. He became an expert in the judging of cotton, and was one of the founders of the St. Louis Cotton Exchange, of which he later became president.

During the Civil War, he joined the 13th Regiment of Missouri, was elected its major and served as such until the close of the war.

On Sept. 7, 1863, he married Miss Hattie E. Basham, Louisville, Ky., by whom he had three children.

His firm, Adolphus Meier & Co., was also engaged in exportation of cotton and of tobacco to Europe. The cotton mill for some years made sufficient profits to double its capacity, but afterward its Eastern competitors were able to get rates from the New England States to the Northwest and Southwestern States so much lower than those from St. Louis to these points that this business suffered severely. There was at that time no Interstate Commerce Commission to regulate rates, and wages were much higher in St. Louis than in Lowell. After a protracted struggle, the cotton factory had to go into bankruptcy. A large shipment of raw cotton exported to London by the firm was burned in Hoboken and the insurance lost on some technicality about Hoboken not being part of the port of New York. Some investments in railroads, coke works, iron works, in which the firm was largely interested, suffered in the depression of 1873, etc., and when the senior Mr. Meier died in 1888, the juniors found the firm hopelessly bankrupt.

T. G. Meier then agreed with his brother, Colonel E. D. Meier, to take up the settling of the affairs of the firm with its creditors if time were given. Such was the confidence reposed by all the creditors in his honesty, capacity and determination, that all made agreements with him out of court, and in the course of 25 years he has accomplished the result.

His tastes were plain, his demands on life modest, and his sense of duty paramount to every other consideration.

For the last twenty-five years he had been vice-president and treasurer of the Heine Safety Boiler Co., of St. Louis, and the phenomenal growth of that company is largely due to his financial ability and careful economy. He was able to give personal attention to his duties until his 78th birthday, but his physician urged him to take a prolonged rest on account of hardening of the arteries. He went to Wequetonsing, Mich., where the climate first seemed to restore him, but he became gradually weaker and passed away Aug. 16.

NEW PUBLICATIONS

Two books have been published dealing with the proceedings of the Fifth National Conservation Congress held in Washington, D. C., last November. One of them treats of water-power subjects exclusively and is an important contribution to constructive literature in this subject. The other book contains the forestry reports and addresses which were conceded to be the most valuable ever presented at a similar meeting in this country. The books may be had for one dollar each through N. C. McLoud, treasurer and recording secretary of the Congress, 1201 Swetland Building, Cleveland, Ohio.

HARPER'S GASOLINE ENGINE BOOK. By A. Hyatt Verrill. Published by Harper & Bros., New York, 1914. Size 5x8 inches; 292 pages, illustrated. Price $1 net.

The extensive use of gasoline engines in automobiles or motor boats by persons having little or no knowledge of their principles of operation, has created a field where this book should have wide circulation. Written in a nontechnical and simple style, the text takes up the fundamentals of the gasoline engine, describes the various types, commenting upon their relative advantages and shortcomings, discusses their care and operation, and enumerates the common troubles and the remedies. The illustrations are well chosen and the author is to be commended for adhering closely to the subject as set forth in the title.

ELECTRIC LIGHT ACCOUNTS. By H. M. Edwards. Published by the McGraw-Hill Book Co., New York, 1914. Size 5x7½ inches; 172 pages; flexible leather. Price, $2 net.

The long experience of the author as auditor of the New York Edison Co. and as an active member of the accounting section of the National Electric Light Association, has particularly fitted him as an authority on the subject of public-utility accounting. The text is grouped under three headings, namely: "Balance Sheet or Indicant Accounts," "Income Accounts," and "Miscellaneous Accounts." The first covers such items as plant investment, current assets, suspense account, liabilities and reserves, and under the second heading are included gross earnings and operating expenses.

The subject is handled logically, and although covering practically all items that any lighting company might be called upon to deal with, the treatment is flexible enough to make it applicable, wholly or in part, to any conditions. The explanations render the text easily understandable, and numerous sample record blanks and cost sheets are included. The author urges compliance and coöperation with public service commissions in the matter of accounts and appears to have followed this throughout the book.

BUSINESS ITEMS

Ingersoll-Rand Co., 11 Broadway, New York City, has recently issued two new catalogs, forms 3024 and 3030, on Ingersoll-Rogler Air Compressors. The former, form 3024, is a complete treatise on the "Ingersoll-Rogler" valve and the latter covers the Class ER-1 type of compressor. Both catalogs are profusely illustrated, showing the details of the machine in section. Copies will be mailed free on request.

The Lincoln Boiler Cleaner Co., Lincoln, Ill., recently received a letter from the St. Joe Ice Co., of Elkhart, Ind., reading as follows: "The two boiler skimmers installed in our plant by the Lincoln Boiler Cleaner Co. have been a great success, removing practically all the scale-forming substances and preventing the deposit of any new matters on the tubes. The skimmers will soon pay for themselves in coal saving and additional steam.

The Yarnall Waring Co., Chestnut Hill., Philadelphia, Penn., has just published a new 88-page treatise on the "Lea" V-Notch Recording Liquid Meter, and anybody interested in this important subject can secure a copy by writing direct to the company. The title of the book is "Log Book of the Power Plant." It is full of interesting and instructive data, is well illustrated and goes into complete details as to how this meter is used for all kinds of liquid measurement, including boiler feed, condenser discharge and industrial liquids of all kinds.

TRADE CATALOGS

Alberger Pump & Condenser Co., 140 Cedar St., New York. Catalog E. Alberger centrifugal pumps, Alberger-Curtis steam turbines. Illustrated, 56 pp., 6x9 in.

The Roto Co., Hartford, Conn. Catalog No. 40. Roto tube cleaners. Illustrated, 6x9 in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1086. Kerosene engine generating sets. Illustrated, 12 pp., 8x10½ in. Bulletin No. 1087. Polyphase induction motors. Illustrated, 20 pp., 8x10½ in.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. Catalog. "The Log Book of the Power Plant." Lea V-notch recording liquid meter. Illustrated, 88 pp., 6x9 in.

National Transit Co., Oil City, Penn. Loose-leaf binder and bulletins Nos. 10 and 11. Pumping machinery. Illustrated.

Murray Iron Works Co., Burlington, Iowa. Pamphlet No. 11. Murray-Corliss engines and alternating-current generators. Illustrated, 12 pp., 9x11 in.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Attleboro Gas & Light Co., Attleboro, Mass., has purchased an 18-acre site and will construct a new plant.

Bids will be received by the Trustees of Public Buildings, Capitol, Albany, N. Y., until 2 p.m., Sept. 10, for heating and ventilating apparatus, plumbing and electric wiring for rooms of the fifth floor of the New York State Capitol. Lewis F. Pilcher is State Arch.

Plans have been prepared for the construction of amunicipal electric-light plant at Bath, N. Y. The estimated cost is $50,00. W. W. Babcock is Chn. of Bldg. Comm.

The Board of Public Utility Commissioners has granted permission to the Riverside Traction Co., Burlington, N. J., to issue bonds for $51,000 for the construction of a new electric power plant.

Bids will be received by the Lighting Committee of the Borough Council, Butler, N. J., until Sept. 14, for constructing a municipal electric-light plant. Runyon & Carey, 845 Broad St., Newark, are the Engrs. George J. Fritz is Borough Clk.

SOUTHERN STATES

The citizens of Rock Mart, Ga., voted to issue bonds for the enlargement and improvement of the municipal electric-light plant.

The State Board, Baton Rouge, La., is having plans prepared by Favrot & Livaudais, New Orleans, for the construction of a new power plant at the State Insane Asylum at Pinesville, La.

Plans are being prepared by W. L. Thompson, Elect. Engr., Boyce, La., for the construction of a municipal electric-light plant at Melville, La. This power plant is to be erected on extensive lines and is to have several sets of high-power machinery.

The municipal electric-light plant of the city of Henderson, Ky., which was recently damaged to the extent of $10,000 by a tornado, will be rebuilt.

CENTRAL STATES

Plans are being prepared for the reconstruction of the municipal power plant at De Graff, Ohio, which was recently destroyed by fire. J. T. Scott is Supt.

The Loveland Light & Water Co., Loveland, Ohio, has been organized with $50,000 capital by Stanley Matthews and associates. The company will take over and reorganize the local electric-light system and water-works.

Plans are being prepared by Frank Van Tuyl, Arch., 1112 Union Trust Bldg., Detroit, Mich., for the construction of a power plant for the Detention Home in Detroit.

Press reports state that the Commonwealth Edison Co. has purchased 21 acres at 100th St. and Ave. N, Chicago, Ill., and will erect a power plant to supply the manufactures with power. William A. Fox, Chicago, is Secy.

WEST OF THE MISSISSIPPI

The plant of the Grundy Center Electric Co., Grundy Center, Iowa, recently damaged by fire to the extent of $10,000. J. B. Calderwood is owner and Mgr.

Press reports state that the municipal electric light, South Stillwater, Minn., was recently destroyed by fire. The estimated loss is $20,000. Paul Pracht is Mgr. and Supt.

The Town Council has granted a 40-year franchise to A. B. and V. B. Johnson, of the Marshall Milling Co., Marshall, Ark., to build and operate an electric-light plant in Marshall.

The State Public Service Commission, Boise, Idaho, has granted permission to Dunkle Bros., Plummer, Idaho, to construct and operate an electric-light plant in Plummer.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c an insertion, in advance.

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

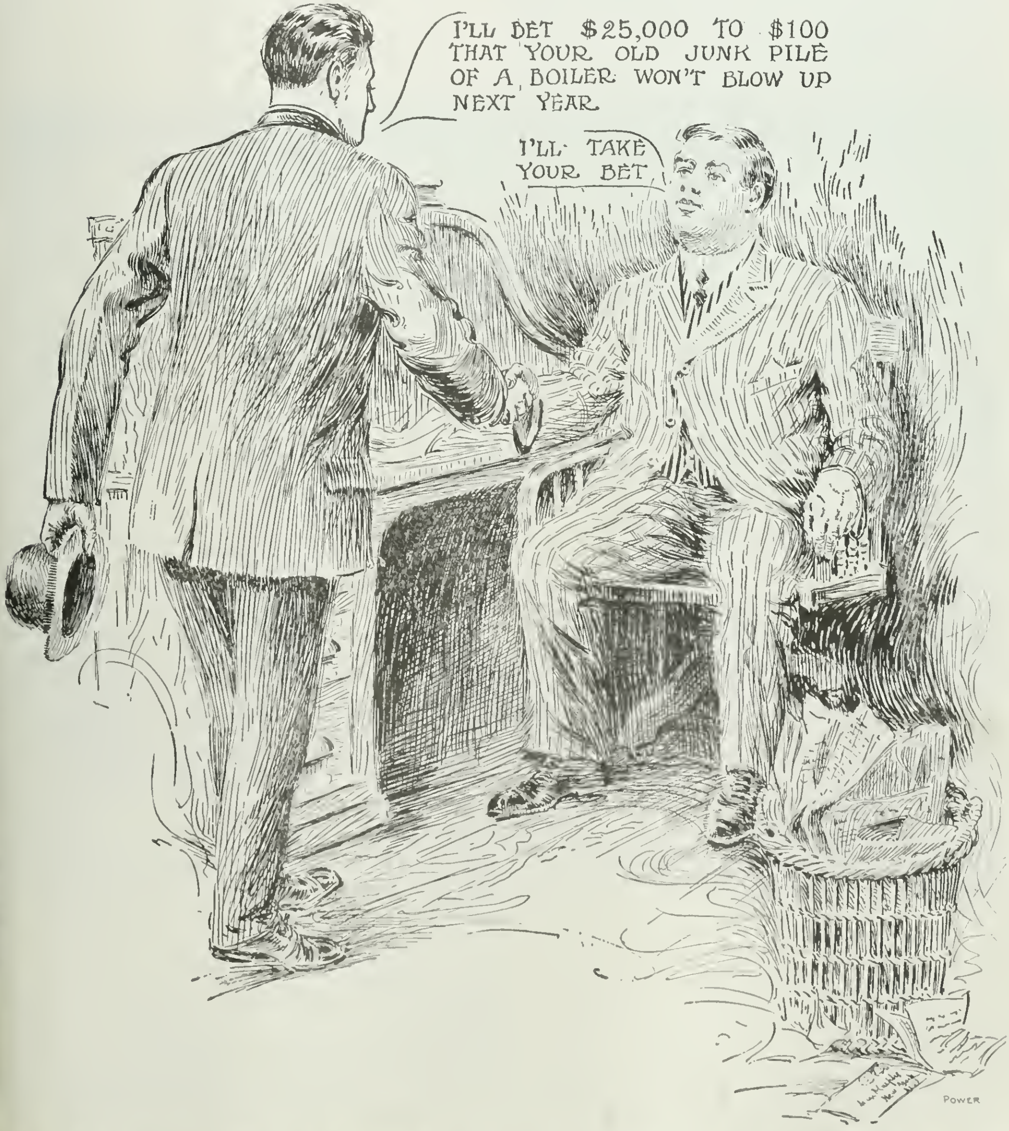
Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

AN A-1 POSITION is open to a good man capable of developing steam specialties and taking charge of manufacturing end of advertiser's business. P. 302, Power.

POWER

Vol. 40 NEW YORK, SEPTEMBER 15, 1914 No. 11


I'LL BET $25,000 TO $100 THAT YOUR OLD JUNK PILE OF A BOILER WON'T BLOW UP NEXT YEAR.
I'LL TAKE YOUR BET
POWER

Is Your Boiler Insurance a Gamble?

German Manufacturing Power Plant

SYNOPSIS—A German manufacturing power plant in which there are two 100-kw., bleeder-type steam turbines, steam being taken from the second stage for heating purposes. The two 3-flue return boilers are mechanically fed. Coal is delivered in cars and the load discharged into a coal pocket by upending the car on a car tipper.

⁂

The development of the Wanderer-Werke Actien Gesellschaft, at Schonau, near Chemnitz, Germany, is an example of present-day industrial growth. In 1885, John Baptist Winklhofer and Richard Jaenicke organized a company for the sale of bicycles, and at first employed two men; today more than 3000 are employed in the manufacture of bicycles, automobiles, typewriters, etc.

The factory is lighted by 200 to 600-cp. metallic-filament lamps on the semidirect system. About 140 lamps are on each floor. Heat is obtained for the factory by using exhaust steam through coils, which comes from the turbine in the power plant at about 37 lb. pressure. The machine tools in the factory are either driven by separate motors or in groups. Before the erection of the new power plant, electrical energy was supplied, for the greater part, by the municipal electric works, but the repeated stoppage or curtailments of the supply during the winter months compelled the building of a private power plant, which has been designed with a view to future extensions. When work was started, the total current consumption in the factory was about 600 kw. for power and 350 kw. for lighting purposes.

Turbine Room

The turbine room has floor space for four steam turbo-generators of 1000-kw. capcity each, at 3000 r.p.m. Two have been erected, Fig. 1. Both turbines are arranged for drawing off steam from the second stage of the turbine for heating purposes. The generators are three-phase, 50-cycle, and supply current at 525 volts.

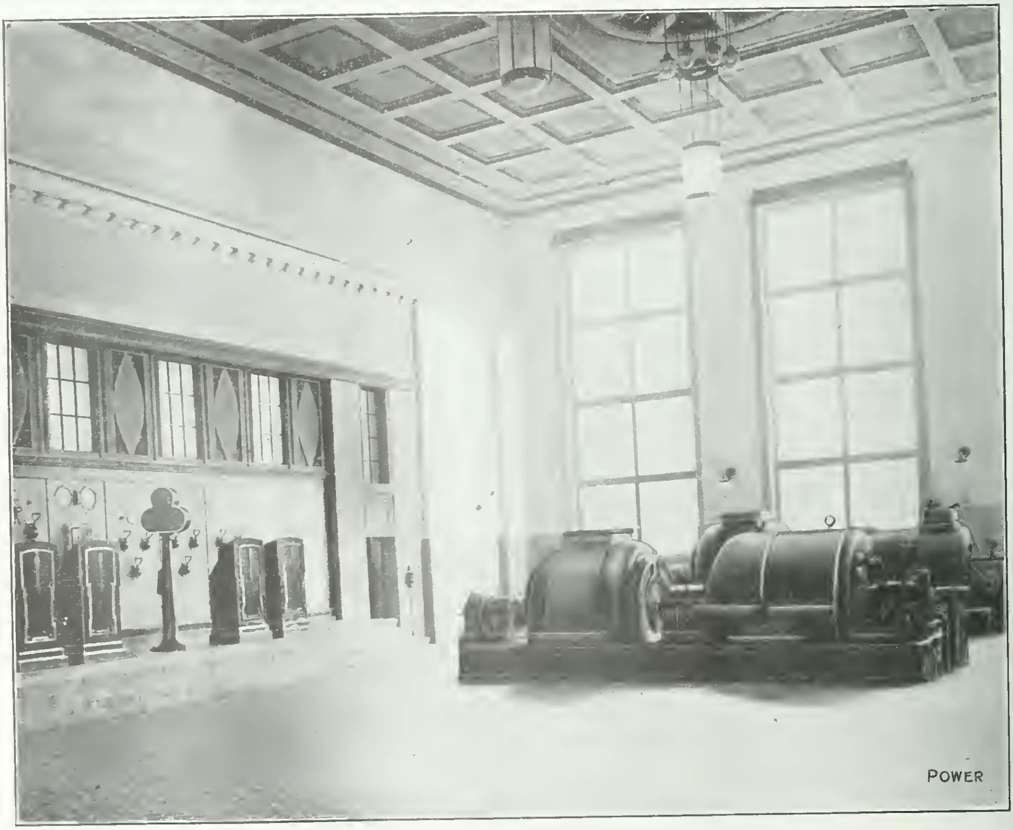


Fig. 1. Partial View of the Turbine Room

As the available water for condensing purposes is limited, a cooling tower is used capable of handling 1321 gal. of water per hour. Motor-operated oil switches are used, and the current for power purposes is supplied by cables to the distribution boards of the various departments at about 500 volts. The current for lighting purposes is transformed down to 290 volts and used as monophase current with a neutral conductor, carrying 110 volts. Although the factory has its own power plant, connections have been made with the local supply so that in emergency, power can be obtained from outside. Although one turbo-generator is kept as a spare unit, the wiring is arranged so that at night, when work is stopped, well pumps and the emergency lighting can be carried by current supplied by the outside company. The emergency lighting system is automatically switched on the municipal circuit if for any reason the current generated by the power plant should fail.

Boiler House

The boiler house is designed for four boilers, Fig. 2, and contains at present two 3-flue tubular boilers in one battery with double steam drums, each boiler having a heating surface of 6479 sq.ft. and working at a maximum pressure of 220 lb. The boilers are equipped with built-in superheaters having a capacity of 16,534 lb. of steam per hour. Furnace gases are carried off by a chimney 236 ft. high and 8.85 ft. inside diameter. The temperature of the gases is 350 deg. C. The boilers are equipped with stokers and water is automatically fed by a duplex steam pump. An auxiliary feed arrangement consists of a motor-driven seven-stage centrifugal pump. The feed water tanks for cold and condensing water are located in a chamber above the pump, so that the water can flow to the pump with a head. The pumps are also connected with the pipe system of the fire hydrant so that in case of fire, water at about 120 lb. pressure is available at any point in the factory. Water for heating purposes, etc., is obtained from a deep well.

Coal is delivered on a railway siding and the cars are run over a weigh bridge and turntable to the boiler house, where the load is dumped into a concrete coal hopper by means of a car tipper, Fig. 3.

A coal conveyor discharges the coal into bunkers above the boiler furnaces, which hold 11 double truck loads each. From these the coal passes automatically into the stoker hoppers.

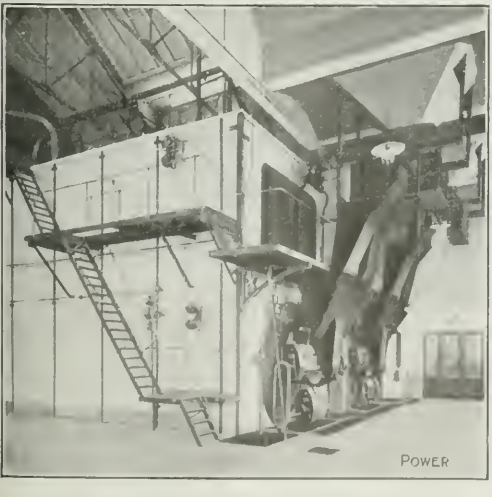


FIG. 2. BOILER ROOM AND TWO THREE-FLUE BOILERS

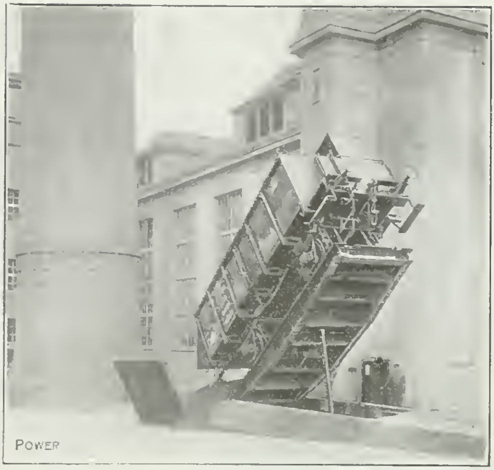


FIG. 3. DISCHARGING A CARLOAD OF COAL TO THE BOILER-HOUSE CONVEYOR

Ashes and clinkers are passed into an ashpit arranged in front of the boilers below the furnaces, and are conveyed from there by cinder cars and hoists to an elevated bunker, from which trucks and railway cars are loaded direct.

The boiler and engine-room floors and ceilings are faced with tile. The engine room is fitted with colored glass windows, paneled ceiling and a lighting installation consisting of 33 metallic-filament lamps of 100 cp. each.

First Aid in Ammonia Accidents

The National Ammonia Co., New York, is distributing large cards giving directions for treating persons suffering from ammonia accidents. These directions, given below, should be of interest to all engineers handling ammonia refrigeration plants:

First summon a doctor, prompt action being of great importance, and until his arrival apply the following remedies:

EXTERNAL

For the eyes: First, pour a 1 per cent. solution of pure boric acid into the eyes, instructing the patient to open and close the lids rapidly to bring the solution in contact with the entire inner surface. Use freely, as the solution is not dangerous.

Second, after thoroughly washing the eyes, place a small quantity of clean, plain vaseline under the lids by pulling down the lower lid and applying the vaseline with a match-shaped piece of wood having smooth, rounded ends.

For the skin. Apply lint or linen or washed muslin dripping wet with carron oil, changing the dressing frequently. (By keeping lime water and linseed oil separately, a fresh solution of carron oil may be prepared each time by mixing thoroughly equal parts of the two ingredients.)

INTERNAL

For nose and throat if inhaled: Dip a handkerchief or a piece of gauze folded once in vinegar, wring it out lightly and lay it loosely over the nose and mouth. (If liquid ammonia has entered the nose, snuff up some diluted vinegar and apply sweet oil with a feather to the inner surface of the nostrils.)

If ammonia has been swallowed: Administer diluted vinegar or have the patient suck orange or lemon juice in liberal quantities and follow with one to four teaspoonfuls of sweet oil, milk, or the whites of three or four eggs and some ice. (If vomiting occurs, aid it by giving liberal draughts of lukewarm water.)

GENERAL INFORMATION

Ammonia gas is lighter than air and, being released, rises. Therefore, in case of accident, keep your head as low as possible.

On going to the rescue of one overcome by ammonia gas keep near the floor and place a wet sponge or cloth over the mouth and nostrils. Water will absorb the gas and prevent its inhalation.

Keep the following supplies on hand in a clean and easily accessible cabinet:

A 1 per cent. solution of pure boric acid, one bottle of clean, plain vaseline, one package of surgeon's lint or muslin, a package of plain gauze, one pint of best quality vinegar, one pint of sweet oil, and one pint of carron oil (linseed oil and lime water, equal parts).

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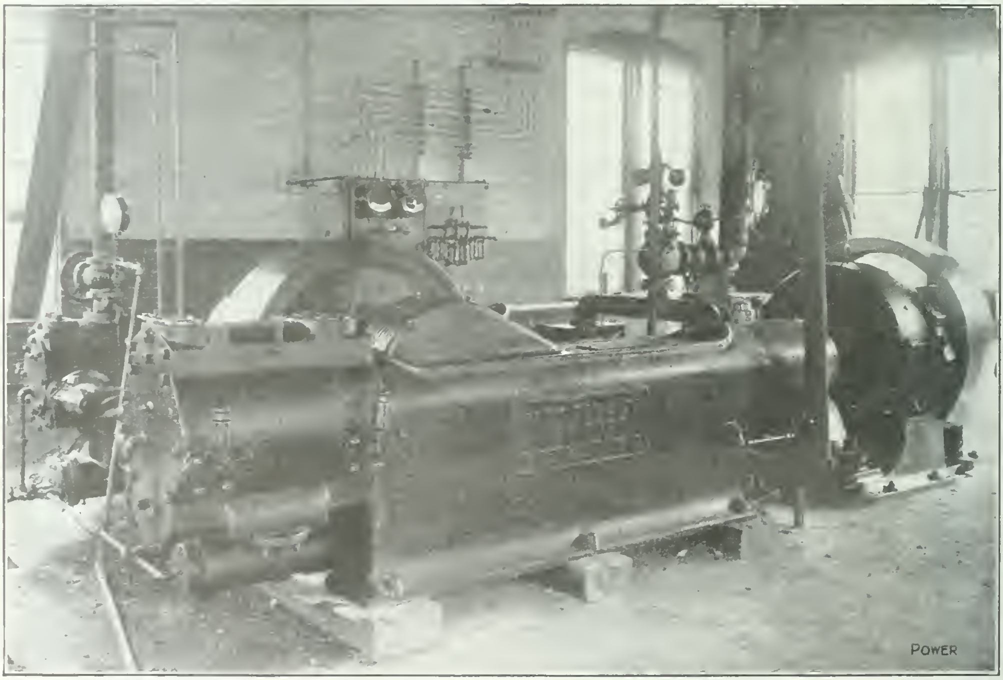
Interesting Air-Compressor Record

By Frank Richards

The accompanying illustration shows an air compressor at the Hollenbeck colliery of the Lehigh & Wilkes-Barre Coal Co. The machine is self-contained, with high-pressure steam cylinders and two-stage air cylinders, the diameter of the former being 12 in. and the latter 18 in. and 11 in., with a common stroke of 16 in.; the theoretical free-air capacity at 150 r.p.m. being 704 cu.ft. per min.



Compressor Operating at Full Speed without Foundation or Anchor Bolts

This compressor was shipped on June 27, 1905, and was immediately set up and put to work. Since then it has been operated continuously 24 hours per day with the exception of a regular stoppage of two hours on Sunday for inspecting the discharge valves and a general cleaning up and looking over. For three or four years past the machine has been too small for the work and has been run at a speed of from 170 to 225 r.p.m.—600 ft. piston speed.

The engineer of the power house states that the cylinders have not been rebored, and that the compressor is still fitted with the same pistons and piston rings, as when shipped from the factory. The discharge valves and discharge-valve springs have been renewed, some of them having been in service for five or six years. There has never been any delay at this colliery that could be attributed to the compressor.

This machine has recently been replaced by a compressor of much larger capacity. When the change was made it was picked off its foundations and placed on the power-house floor upon three 12x6-in. timbers as shown, without bolts or fastening of any kind, the pipe connections were made, and the compressor was started up and is still running at its highest speed.

The illustration shows the compressor running, as is indicated by the disappearance of the flywheel arms, but the governor is not running, as the driving chain is not in place. The sharpness of detail shows the absence of jar or vibration.

The machine has had the best of care and systematic inspection. The oil, for instance, has been taken out of the crank cases and filtered every three weeks and make-up oil added. Beyond this care, the engineers have exercised the happy faculty, sometimes painfully lacking, of letting well enough alone and giving things a fair chance. For the information here presented the author is indebted to William Wilhelm, of Philadelphia.

Electrically Operated Steam-Pressure Regulator

By Ernest Giles

The regulator described herewith has been in constant use 24 hr. a day, six days a week, for over four years in the news-paper mills of the Finch-Pruyn Co., Inc., Glens Falls, N. Y., on its largest machine, and has proved so satisfactory that another machine is to be equipped with a similar regulator.

The machines, previous to the installation of the electric regulator, were each equipped with a hydraulic regulator, which gave fair satisfaction, but would go out of commission every time the water pressure was turned off, therefore, as the electric service was dependable, an electric regulator was desirable.

In paper-mill practice, the engine driving the machine exhausts into the machine dryers and furnishes most, if not all, of the steam heat used. Under some conditions live steam is necessary to help out.

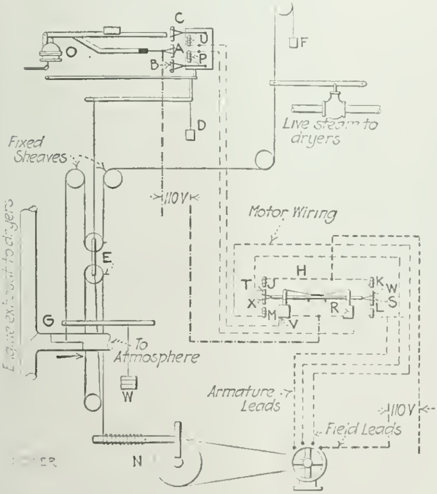


Fig. 1. Arrangement of the Exhaust and Live-Steam-Valve Control

Fig. 1 shows the arrangement of the exhaust- and live-steam valves, also the manner of connecting them jointly with a cable, so that no live steam will be used unless the exhaust from the engine should be insufficient. The exhaust valve is held closed by a heavy weight attached to the valve lever, to which one end of the cable is attached and then passed over a fixed and a movable sheave with an up-and-down travel; then over two more fixed sheaves connecting to the live-steam valve lever. This valve is free to open with the pressure as the cable becomes slack by an upward travel of the movable sheaves, the exhaust valve remaining closed. A downward travel of the movable sheaves will first close the live-steam valve and then open the exhaust valve. The exhaust cannot be opened until the live-steam valve is closed, as the weight *W* on the exhaust is sufficient to hold the live steam closed.

The illustration shows the arrangement of the diaphragm weight lever, which adjusts the pressure to the amount required; this lever also carries the contact *A*, which has an up-and-down movement with the lever.

Below and above the contact *A* are *B* and *C*, which are moved up and down by the travel of the movable sheaves, connected in the valve-operating cable, and serve to compensate the regulator. These contacts are mounted on the ends of armatures, which also have a slight up-and-down movement, being operated by small electro-magnets, one just below the upper and one just above the lower contact. Any current passing through them must also pass through the small electro-magnets, thus drawing the contacts *B* or *C* to a closer connection with *A*. This is necessary, otherwise the contact would be poor and unsatisfactory, due to the light pressure exerted by *A* in closing against *B* or *C*.

The contact *A* will always have a slight movement up and down, due to the engine exhaust (the regulator diaphragm is connected to the dryers to which the engine exhausts), which would aggravate the poor contact of *A*. This fault is overcome by the arrangement shown.

The weight *D* hanging from the compensating arrangement prevents all lost motion and lowers the contacts *B* and *C* when the movable sheaves *E* travel upward. The weight *F* is to hold the cord tight, thereby keeping it on the sheaves when moving the regulator by hand and the steam is off; also, while inspecting the apparatus when the paper machine is not running.

Excessive pressure in the dryers will blow the exhaust valve *G* open, the weights being proportioned to admit of such action.

The relay *H* is an electrically operated reversing switch, and serves to start the motor in either direction and to open the motor circuit at the proper time. It is controlled by the contact *A*. There are two solenoids, one on either end of a lever and connected to it through their plungers by flat flexible springs, as shown. The lever rests on two knife edges indicated by the two small arrows and so placed that when no current is flowing through either coil the lever stands in the position shown, with the motor circuit open in two places.

Relay contacts *J* and *K* are hinged and make just before *L* or *M*, which is necessary to allow for any slight wear of the $\frac{1}{2}$-in. contact carbons.

The cable control *N* consists of a shaft carrying a light wooden pulley belted to the motor and a worm which meshes with a wheel on another shaft carrying a drum upon which the free end of the lower controlling cable is wound or unwound. It is driven by a small series wound fan motor.

The operation of the system is as follows: Consider that the steam pressure under the diaphragm *O* has been holding the weighted arm in the position shown, but for some reason it drops a little; the balance arm will then lower, carrying with it the contact *A* until it makes contact with *B*. The path of the current will be through *A* to *B* and then through the magnet *P*, which will instantly hold *B* in contact with *A*. From *P* the current will flow through the relay coil R, closing the relay contacts S and T against L and J.

With this position of relay contacts there is a path through the motor fields to the contacts L and S to the left-hand armature lead, through the motor armature, and then to the contacts T and J and to the line. This will start the motor in the direction to unwind some of the cable wound on the drum X which allows the movable sheaves E to rise. The slack in the cable connecting the valves will be taken up by the live-steam valve, which will open a little.

At the time that the sheaves E move upward the contact B will be lowered, breaking contact with A, which allows the relay to assume its normal position and shut off the current to the motor, thus stopping any further movement of the valves. If this movement is not enough to check the lowering of the pressure under the diaphragm, the cycle of operation will be repeated until the arm again assumes a balanced position.

Considering that the pressure rises and that A makes connection with C, there will be a path from A and C and the magnet coil U to the relay coil V, causing K, W, X and M to make contact. The circuit will then be starting with the right-field coil through the motor fields to M and X through the right-hand armature lead W and contact K and to the line. The motor will then run in the opposite direction and will wind the cable on the drum X. This causes the movable sheaves E to lower, which will take up the cable connecting the valves and close the live-steam valve if it should be open; if it is closed, it will open the exhaust valve a little, because when the sheaves E move downward they cause the contact C to move upward, breaking connection with A and opening the circuit through the relay coil V. This causes the relay to assume its normal position, opening the motor circuit and stopping the motor. If the pressure still goes up a little, this cycle of operation will be repeated until a balance is obtained at the weighted balance arm.

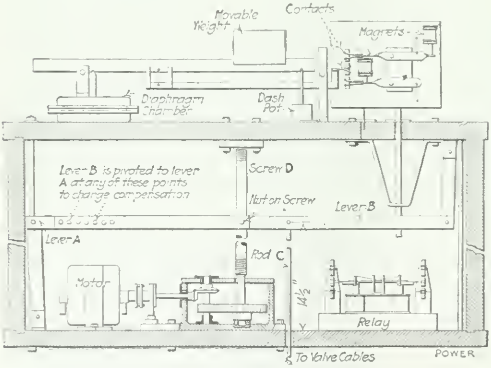


FIG. 2. THE IMPROVED REGULATOR

The amount of compensation, however, has been so proportioned that more than one movement of the valves seldom occurs, immediately following another. The regulator to be used on the other machine, while essentially the same so far as operation is concerned, varies mechanically.

The arrangement of the diaphragm lever and its movable weight is practically the same, as are the contacts. A dashpot is used. Perhaps the greatest difference in the two regulators lies in the manner of imparting power to the valve cables and in the type of motor.

With the regulator, Fig. 2, there is a three-phase motor directly connected to a lever to work the cable, through a train of gears in an oil-tight case. This does away with the necessity of belting the motor and also with a drum to wind and unwind the cable controlling the valves.

In considering the action of the regulator, starting at the motor, the action of the contacts and the relay is the same as has been described. The motor is connected to a screw D through the gears shown, there being a flexible coupling between the motor and gear shaft. The screw D carries a nut to which the lever A is attached and serves to move the lever up and down.

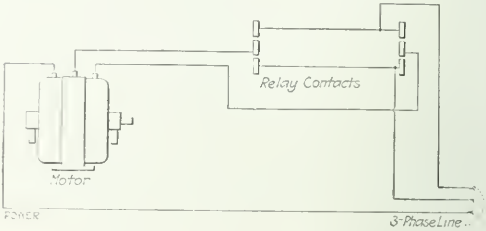


FIG. 3. WIRING OF THE THREE-PHASE MOTOR

Lever A is pivoted at the left end to a link which is fast to the bottom of the case, which contains all the parts.

At the right of the lever A is attached the rod C which works the valves, its operation being the same as the other regulator.

The lever B is pivoted at the right end to a link made fast at the top of the regulator case and at the left to the lever A at one of the numerous holes shown, thus increasing or diminishing the amount of compensation. Once properly adjusted, it need not be changed.

If the pressure drops, the motor will be started by the action of contacts A and B, Fig. 1, in a direction to move the nut down on the screw D carrying with it the lever A, which will lower B until the contact B breaks with A, stopping the motor. If the pressure rises, the reverse will take place.

The wiring of the three-phase motor is shown in Fig. 3. This motor is wound for 40 cycles, 220 volts, and is rated at $^1/_6$ hp. at 1160 r.p.m. One wire from the three-phase supply runs direct to the motor and is not opened at any time. The direction of rotation of the motor is changed by reversing the two line wires going to the relay.

⁂

Decoration Influence Illumination—The reason the color of the interior of a room influences its illumination is that an object absorbs rays of light of a color different from its own and reflects the rays similar to its own. Grass, for example, reflects the rays of green in the sunlight and absorbs most others. Therefore it is a poor reflector of sunlight. Hence, the necessity of ascertaining the quality—the color composition—of a source of light and decorating in colors similar to those predominating in the light.

⁂

Relative Strain on Boiler Seams—It is well to remember that the strain on a unit section in a longitudinal direction (lengthwise) on a boiler of any given size is just one-half that in a circumferencial direction.

Facilities for Plant-Repair Work

By Lewis Jones

SYNOPSIS—Necessity often causes unusual means to be resorted to and produces modification in types of machines used. A few of these are shown and described.

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Many times the tools and machines for doing repair work about a power plant prove interesting by reason of the skill and ingenuity displayed in their arrangement and use in cases of emergency.

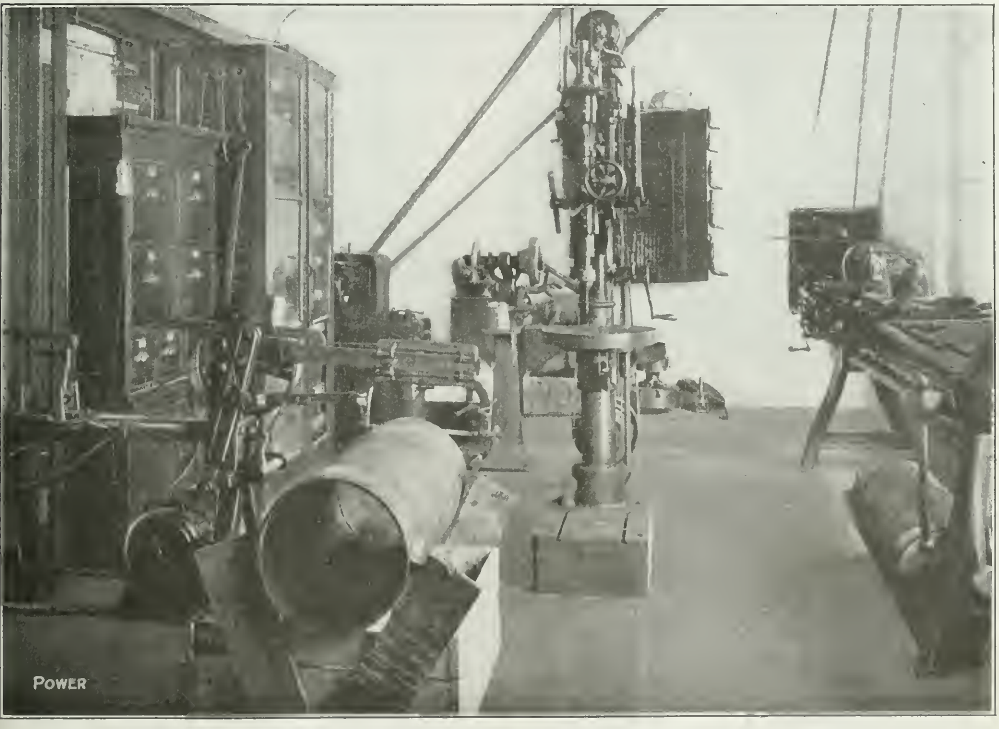


Fig. 1. General View of a Private Repair Shop

Fig. 1 is a general view of such a shop. The equipment is a 16-in. swing lathe driven by an old veteran of a motor to be seen in the corner; an emery grinder driven by an independent motor, and a drill press driven by a small motor, to be seen on top of the machine. At the time this photograph was taken, an interesting job was under way on the hacksaw in the foreground, i.e., a 14-in. pipe being cut to length with a hacksaw. The largest lathe would just swing a pipe of this size over the ways and not permit the tool carriage to be used for cutting off, but when the pipe was cut to length, it could then be threaded from the end with an offset tool.

It was a matter of choice whether the work should be done on the premises, where the threads had to match a bad lot of flanges, or ship them 40 miles and back to have the work done in another shop.

The saw frame and guide were reversed from their normal position so that they extended beyond the rear end of the machine, and the pipe was laid on the top of a shipping box to which slant cleats had been nailed. The dark line on the inside of the pipe is the saw cut, and it will be seen that the saw hardly reached through the wall of the pipe before the ends of the frame began to strike at each stroke; therefore the pipe had to be rotated slightly at frequent intervals with a monkey-wrench on the end of the pipe, and since no clamping was necessary, this could be done while the saw was in motion. It was found best to allow the pipe to rest on the edge of the box rather than in the V-notch formed by the cleats, and the slight motion taken up by a wedge, because in that way the pipe was always level.

The actual time required to thus cut a pipe was less probably than would have been necessary to center and cut it off with a tool in a lathe. The clutch pulley on the saws so obviated the necessity for shifting the belt that the motor set directly below the shaft needed the standard-width pulley only. A flexible cord to a lamp socket was used so that the whole machine could be shifted to suit the work.

Fig. 2 shows the compact arrangement whereby one motor drives an emery grinder and a small drill press, making a handy combination for power-house work.

Fig. 3 shows a motor-driven, 6-in. pipe-threading machine. The motor is mounted above the machine on studs similar to the others, which will be described later,

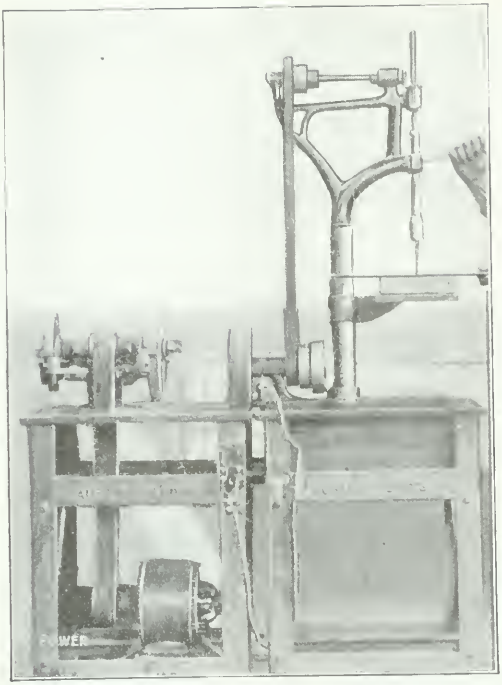


Fig. 2. A Compact Unit

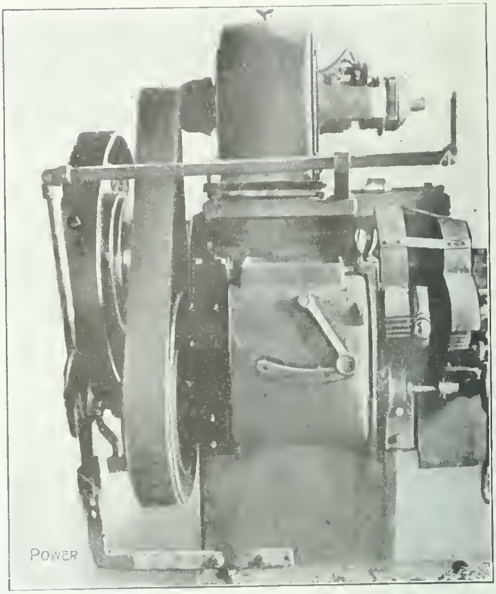
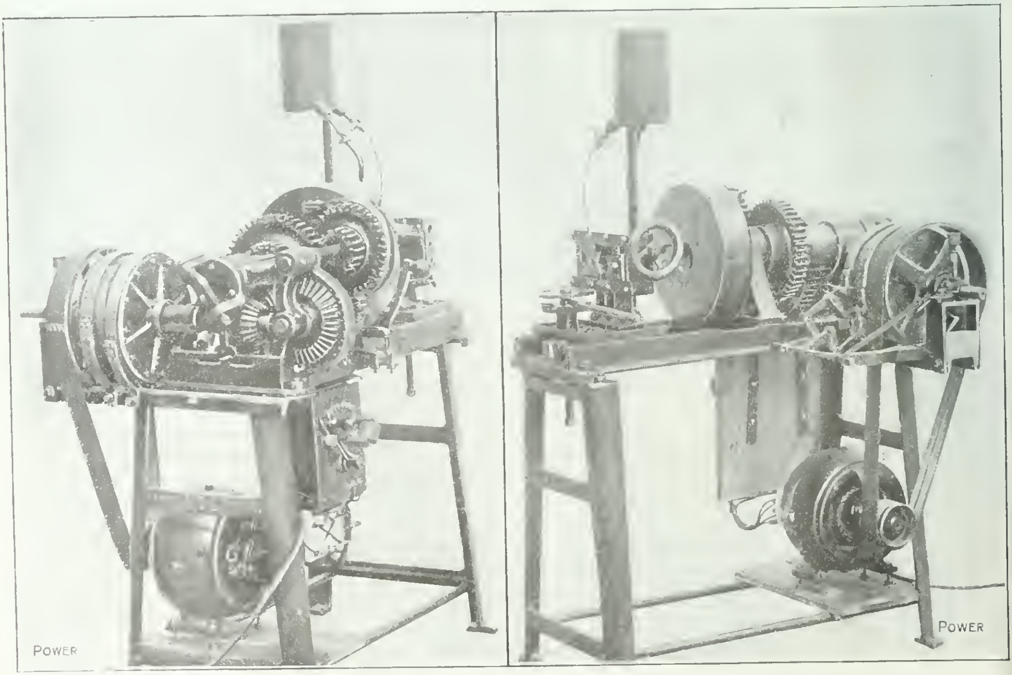


Fig. 3. A Six-Inch Pipe-Machine Drive



Figs. 4 and 5. Unique Drive on a Pipe Machine and drives the clutch pulley on the machine. When bought the machine was intended to be driven in the regular way; that is, the motor was to be belted to a countershaft, which was belted to another by a straight and crossed belt, and from this second countershaft to the machine. The advantages are obvious in dispensing with three of the four belts, and the one remaining can be tightened at will by lifting the motor. When it is necessary to reverse the machine, which is not frequent, a double-throw switch on the field lines is used.

Probably the most interesting of the group are Figs. 4 and 5, which show a motor drive on an old-style Saunders pipe machine for sizes up to 2 in. The head stock was reversed to get the drive away from the operator, and it was also set over on its base 2½ in. toward the operator's side to equalize the weight and to avoid too much overhang. A 3-in. channel iron was used for this purpose, making a rigid support for the outboard bearing. The drive has a planetary transmission of the familiar type used on automobiles, a gear reduction of 3 to 1 on the forward and slow reverse, and a high-speed reverse to be used after the die is slightly freed by about one full turn back at slow speed. All the motions are controlled by a single lever and without reversing the motor. This lever is shifted toward the die-carriage for threading, and in the opposite direction for backing out; in the central position it is pulled sidewise for high-speed backing out. All the motions are friction-clutch controlled, therefore no sudden shock is thrown on the gears or motor and no two clutches can be engaged at the same time. A high-speed motor was selected on account of its light weight.

The gear reduction allows high belt speed without having to use large pulleys. The motor is mounted on the frame almost directly below the drive shaft on four adjusting studs, being raised or lowered on these studs to adjust the belt tension, and held in position by locknuts. The illustrations show the method of mounting these motors, which has proved satisfactory in sizes up to 25 kw. As the whole outfit is mounted on the same stand, it is easily transferred from one job to another and need not be bolted down.

⁂

Weir Measurement of Condensate and Makeup

An interesting application of the liquid meter, which in this case is the Lea V-notch recorder, is that for measuring the different sources of the total boiler-feed water in a plant operating condensing and using economizers. There are three recorders mounted on a meter tank designed for that many, the tank being planned on a closed heater section.

The idea of the multiple recorder apparatus is to measure the discharge from more than one source. For example, in this plant there are two condensing turbines, therefore there is a recorder and its hotwell to measure the condensate from each turbine separately; the third recorder measures the makeup water. A balanced control valve in the makeup water line, operated by the usual float and lever in the main hotwell below the meters, automatically admits the necessary amount of makeup when there is not enough condensate returning to feed the boilers. The feed pump draws its supply directly from the bottom of the hotwell.

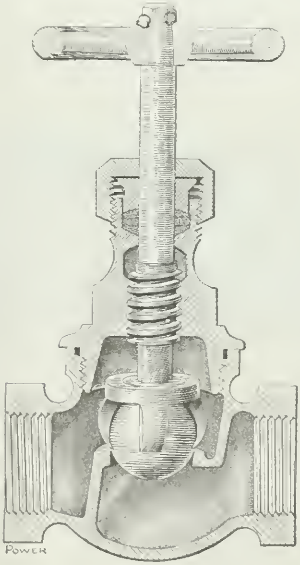
As it is desirable to have the feed water enter the economizers at 150 to 160 deg., to prevent sweating of the tubes, and as the condensate leaves the condensers at between 80 and 90 deg. F. and the makeup water enters the hotwell at a considerably lower temperature (usually dependent upon the outside atmospheric temperature), it becomes necessary to introduce a heating element to raise the temperature of the boiler feed to the proper entering temperature for the economizers. This condition has been met by introducing in the hotwell of the meter a tubular heater, which receives exhaust steam from the boiler-feed pump or some other auxiliary.

In the Hartford Medical School, Boston, Mass., this application of the recorder is used to measure returns from three different buildings.

⁂

Farrell Ball Valve

The special feature of this valve is that a ball of hard-rolled brass or noncorrodible nickel steel is used, as illustrated, instead of an ordinary disk. The ball is held loosely by the claws which rest and revolve freely on a flange on the end of the spindle, the flanged end of which is concaved and bears directly on the top of the ball, holding it rigidly on the valve seat when closed.



FARRELL BALL VALVE

This bronze valve, in pipe sizes from ½ to 2 in., is made by the Pratt & Cady Co., Inc., Hartford, Conn.

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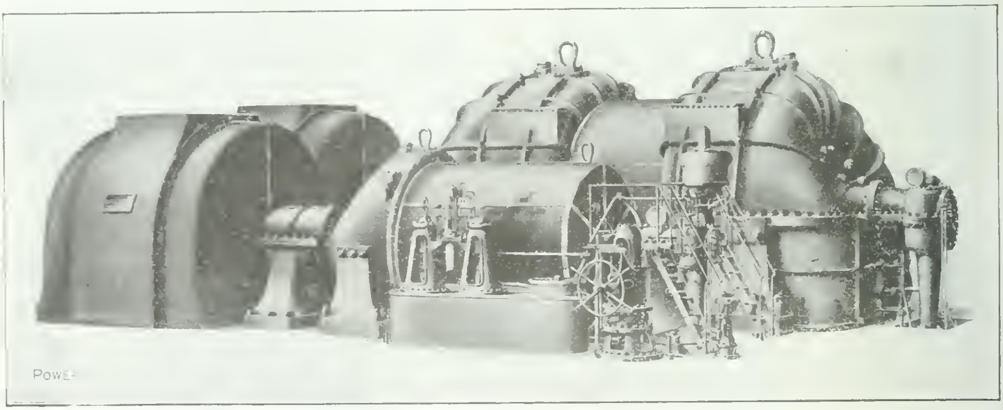
Evidence of Earnest Effort in the Cause of Smoke Abatement—About 60 railroad executives met on Aug. 4, at the call of Chief J. W. Henderson, of the division of smoke inspection in Pittsburgh, to find out what the railroads are doing to abate smoke in that city. Three months ago men were appointed to watch the different engine crews and the result has been that it was decided that the success of the plan remains with the engine crews, and that it is up to them to hold the smoke emitted to the minimum. Progress is undoubtedly being made in this city in the smoke-abatement problem

Compound Steam Turbines

By Francis Hodgkinson*

In some recent turbine installations, and in the case of some machines in the process of construction, two cylinders have been employed for a single turbine-generator unit, the steam passing serially through the turbine elements as in a two-stage compound engine. In some instances, the turbine elements have been arranged tandem fashion, coupled to a single generator, and other units not yet in operation will comprise two turbine elements driving separate generators. By many this will no doubt be regarded as a strange proceeding and a retrogression to obsolete practice, inasmuch as several tandem-compound machines of from 1000 to 2000-kw. capacity were built in this country as far back as 1900, subsequent to which the design was abandoned. These old two-cylinder turbines have all proved remarkably economical machines, and are still performing excellently from every standpoint, except where they have been replaced with machines of greater capacity.



30,000-Kw. Westinghouse-Parsons Steam-Turbine-Driven Unit

The single-flow high-pressure section runs at 1500 and the double-flow low-pressure section at 750 revolutions per minute

Many of the reasons which have led to the present adoption of the two-cylinder construction are the same as dictated that design in the past.

Up to 1900 few turbines had been constructed of greater capacity than 500 kw. At that time, however, a machine of approximately 2000-kw. capacity, operating at 1200 r.p.m., which was constructed with but a single cylinder, was installed at the plant of the Hartford (Conn.) Electric Light Co. Simultaneously, a machine of 1000-kw. capacity, in which the expansion was carried out in two separate turbine elements arranged turbine fashion, was built by C. A. Parsons & Co. for the Elberfield Corporation of Germany. The results obtained on these two machines are reported to have been as follows:

Elberfield Turbine		Hartford Turbine
1250 kw.	Load	1998 kw.
145 lb.	Steam pressure	155 lb.
18.5° F.	Superheat	55° F.
28.1 in.	Vacuum	27.3 in.
19.6 lb.	Steam consumption per kw.-hr.	19.1 lb.

This single-cylinder Hartford machine was very much the largest turbine that had been attempted, and excited considerable comment, particularly among European turbine builders, it being regarded by them as a big undertaking to construct a machine of such large capacity in a single cylinder. The effect of the Hartford installation was to very materially increase the range of capacity in single-cylinder turbine construction on both sides of the Atlantic. At the same time, engineers in this country were much impressed by the simplicity and safety of construction offered by the double-cylinder design, which resulted in about 16 machines being built by the Westinghouse Machine Co., ranging in capacity from 1000 to 2000 kw., operating at speeds of from 1200 to 1800 r.p.m.

There was an additional reason which led certain engineers to the two-cylinder design at that time, viz., the fact that reheaters were very fashionable among builders of reciprocating engines. However, for such sizes of machines the two-cylinder construction was soon abandoned because of the enormous length of the units and their greater cost; a 1250-kw. turbine-generator unit was 42 ft. 6 in. long. Single-cylinder machines have now been successfully built up to 20,000-kw. capacity, although the advantages of the two-cylinder construction have been fully appreciated for large-size machines, and still are, if for no other reason than that either element of a compound turbine deals with substantially half the heat drop, and consequently is not subjected to mechanical limitations. No compromises to the blade distribution or number of turbine elements employed need be made for mechanical or structural reasons. The advantages of the two-cylinder construction might be enumerated as follows, these reasons having more force the larger the capacity of the machine:

1—Smaller cylinder structure.

2—Smaller temperature range within a single cylinder.

3—No limitations to the design preventing the attainment of the highest efficiency.

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*Engineer turbine department, Westinghouse Machine Co.

4—Possibility of separating moisture midway in the expansion of the steam.

In the case of machines of 20,000-kw. capacity or above, intended for operation in large power houses where the units, if operating at all, are running at or near their most efficient load, considerable capital investment is warranted for the sake of a comparatively small actual gain in steam consumption; and for a unit of such capacity it is considered that the greater initial cost of the two-cylinder construction is entirely warranted.

In the instance of some 30,000-kw. turbines about to be installed, an innovation in two-cylinder construction has been made in having each turbine element drive a separate generator, each operating at a different synchronous speed, the speed selected being that which will permit the design of turbine best adapted for the expansion range involved. In any turbine designed to completely expand the steam, the low-pressure blading limits the capacity. Considerations of centrifugal force limit the diameter of the last disk or drum. With this at a given diameter, there is a limiting dimension of blade which may be employed. A blade height of 15 per cent., or at most 20 per cent., of the diameter of the drum is not exceeded. To do so involves losses due to the disparity of tip speed and root speed of the blades, there being no steam speeds to best satisfy the two extremes. With the given dimensions of blade passages, the weight of steam which may be passed depends on the desired limit of expansion, *i.e.*, the vacuum to which the turbine is to expand and the desired velocity of steam, which latter should bear a definite ratio to the blade speed.

In the case of reaction machines designed for high vacuum, and with blade speeds of 400 ft. per second or more, it is customary to proportion them so that the steam velocity in the last row of blades approaches the critical point at full load. This so called critical velocity is the highest obtainable with a rounded orifice and without recourse to diverging nozzles. This critical velocity varies from about 1500 ft. per second in the case of high-pressure ranges to about 1200 ft. per second for exhaust conditions. It is the point of expansion in a nozzle where the rate of increase of steam volume is equal to the rate of increase of velocity. Above this point, the velocity increases more rapidly than the volume, and below it the volume increases more rapidly than the velocity.

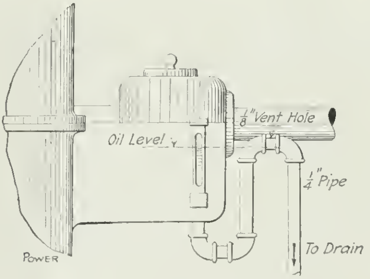
While the limitation of turbine capacity at the low-pressure end is that of providing area on account of the large number of expansions involved, the problem at the high-pressure end of the turbine is in dealing efficiently with the very minute volumes of steam there involved. Plainly, therefore, the best speed having been selected for the low-pressure portion, the design of the high-pressure portion is very much simplified by being able to employ a higher rotative speed. Hence for the 30,000-kw. machines, the high-pressure turbine is a single-flow reaction element operating at 1500 r.p.m., while the low-pressure is a double-flow machine operating at 750 r.p.m., the general design being styled "cross-compound" unit, the general appearance of which is shown in the illustration. The difference in electrical efficiency between a single unit of 30,000 kw. and a 30,000-kw. machine comprising two elements is not material and is far more than offset by the advantages to the turbine of the two rotative speeds. This cross-compound principle will permit of turbines being designed in what are, in effect, single units up to 50,000 or 100,000 kw. capacity, should machines of such large capacities be required. In the case of such sizes, three stages would probably be employed.

Saving Oil in a Power Plant

By Jesse L. Best

One of the numerous leaks that may exist in a power plant is the loss of lubricating oil from auxiliary bearings such as a small steam turbine, especially when it is operating under high back pressure. The same applies to pumps having packing glands close to the bearings. Usually, these machines are equipped with good ring oiling bearings requiring little attention, but if a leak should develop, unnoticed at once by the operator, the oil will soon be flooded out and then there is a hot bearing with its usual accompaniment of wasted oil, and in some cases a shutdown of the unit. If it happens often, a new bearing is required.

In a certain power plant several small turbines operating on back pressures of from 2 to 15 lb. had been giving trouble from leaky packing glands. Part of the steam blowing into the bearings and being condensed, would raise the level of the oil in the bearing and flood it out. The resulting hot bearing was annoying and expensive, especially as the units were required to operate twenty-four hours a day.



Water Drain from Oil Reservoir

To overcome this trouble the writer connected 1/4-in. nipples and ells to a bearing as shown in the illustration. On the first bearing a saving of 1/2 gal. of oil per day was made, and in a week this paid for the time and material. In addition to this saving, the cost of attendance is less and the service more continuous.

As the illustration shows, the idea is to automatically drain the water from the bottom of the bearing without taking along any oil. The oil level cannot be any higher than the overflow or top nipple.

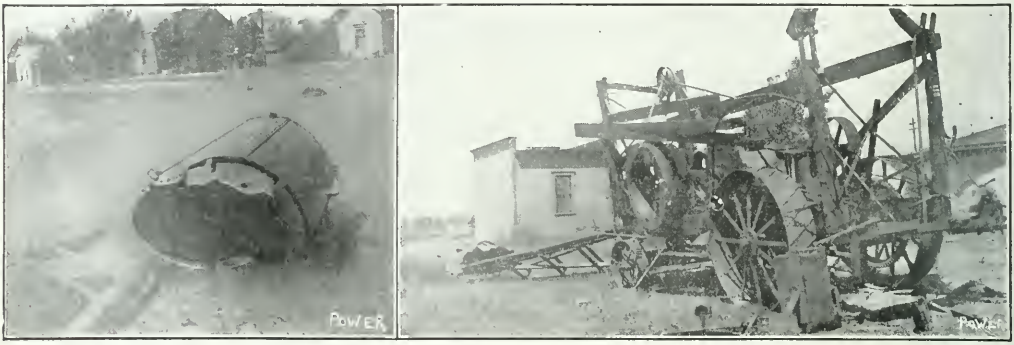
To make this device operate most economically, the piping to the bottom of the bearing should first be filled with water; then oil is poured into the bearing up to the proper level. As soon as any water accumulates in the bearing the oil level will tend to rise and the water in the bottom of the bearing will be forced out through the overflow.

Bearings equipped with this device have run for days without attention, when before they were a constant source of annoyance. It takes only a little vapor from the packing to gradually fill up a bearing. The proper thing, of course, is to keep the packings in first-class order, but the above precaution can be taken at such small expense that it will be found worth while.

Boiler on a Well Driller Explodes

A vertical boiler attached to a Keystone well driller exploded on Aug. 13, at Leipsic, Ohio, seriously injuring two men who were standing on the rear platform at the time.

The boiler had not been in use for about two years and the sheets had corroded almost through in some places.



Boiler and Drilling Rig after the Explosion

* * *

Soft-Coal Smoke as Legal Nuisance

By A. L. H. Street

SYNOPSIS—Mere discharge of dense smoke does not constitute a nuisance. Whether a property owner may enjoin continuance of practice or recover damages is largely dependent upon location and other particular circumstances. Power of cities and legislatures to impose restrictions. What the higher courts have decided.

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From the large body of judicial decisions which have been announced by the appellate courts of the country on the subject of the remedies of individuals and the public against the emission of smoke from power plants, the following may be said:

The mere fact that dense smoke is emitted from a stack does not constitute an actionable nuisance. "It only becomes a nuisance," holds the Minnesota Supreme Court, "when it permeates the air surrounding people and invades their residences and places of occupation." (State vs. Chicago, Milwaukee & St. Paul Ry. Co., 130 *Northwestern Reporter* 545.) A similar conclusion has been reached by the courts of other states. The degree of freedom from smoke in the atmosphere to which one is entitled is relative, and depends on the locality and the prevailing use to which property there is put. What might constitute a nuisance in one locality would be what reasonably might be anticipated in another. Whether smoke or noise constitutes a nuisance depends on the evidence in each particular case. (Iowa Supreme Court, 118 *Northwestern Reporter* 786.) In this case (McGill vs. Pintsch Compressing Co.) the court, finding that the air must be more heavily laden with smoke in one locality than in another, in the reasonable enjoyment of property, declares: "Only when an unreasonable amount of smoke is emitted or is emitted in an unreasonable manner so as to inflict injury on another will the courts interfere. There is no precise test by which to determine when the smoke imparted to the atmosphere is of a greater degree than is permissible. The injury must be tangible. Mere annoyance is not enough. It must be such as to render the occupancy of the complainant's premises physically uncomfortable to a person of ordinary sensibilities for the purposes to which it is devoted."

Validity of Laws and Ordinances

The emission of dense smoke into the atmosphere in populous cities may be declared by the legislative department to be a public nuisance. (Minnesota Supreme Court, 130 *Northwestern Reporter* 545.) In this case the court upheld the validity of an ordinance of the city of Minneapolis which prohibits the use of soft coal in traction engines and locomotives within the city. It was decided that the ordinance was not unconstitutional as constituting class legislation, because it did not extend to stationary engines, since there is a difference in the tendency of that class of engines to produce a nuisance, and since the city had taken other appropriate steps to prevent emission of smoke from stationary plants. The Minnesota court said: "It is elementary that the legislature cannot prevent a lawful use of property by declaring a certain use to be a nuisance which is not in fact a nuisance, and prohibiting such use. On the other hand, it is equally clear that acts or conditions which are detrimental to the comfort and health of the community may be effectively declared nuisances by the legislature, and the fact that the use or value of property as existing under the common law is thereby injuriously affected does not necessarily bring such legislative action within any constitutional prohibition."

A law enacted by the New York Legislature in 1895, providing that no factory, engine room or electrical station should use soft coal for fuel within a radius of four miles of the Brooklyn city hall, except for heating and welding iron or steel, was upheld by the Appellate Division of the New York Supreme Court as being a proper exercise of the state's police power. (City of Brooklyn vs. Nassau Electric R.R. Co., 61 *New York Supplement* 33.) In a later case (City of New York vs. H. W. Johns-Manville Co., 85 *New York Supplement* 757) it was held that there was a showing of violation of the law on proof that about 20 per cent. of the coal used by defendant was soft coal.

An ordinance of the city of Indianapolis declaring the emission of dense smoke from any chimney, etc., within the corporate limits to be a public nuisance, irrespective of the particular locality, was sustained by the Supreme Court of Indiana, although the ordinance excepted from its operation private residences. (Bowers vs. City of Indianapolis, 81 *Northeastern Reporter* 1097.)

An ordinance of the city of Chicago forbidding discharge of dense smoke into the open air has been upheld. (161 *Illinois Appellate Court Reports* 307.)

The St. Louis Court of Appeals has declared that the provision of the Missouri statutes which makes it a good defense to a prosecution for discharging dense smoke into the open air that there is no known practicable device, etc., by application of which discharge of dense smoke could have been prevented, is not available as a defense in a prosecution for violating the anti-smoke law of that state, where the offender installs or unreasonably maintains boilers to which no smoke abatement appliance can be attached. (State vs. Dower, 114 *Southwestern Reporter* 1104.) This law makes it a misdemeanor to discharge dense smoke into the open air in cities having more than 100,000 population.

But, in a late case, the New Jersey Supreme Court has held that an ordinance forbidding the emission of smoke from any locomotive or engine stack within the limits of Jersey City, containing soot or other substance in sufficient quantity to injure health or property, is unreasonable, so far as locomotives are concerned, as being in derogation of a railway company's right to emit such smoke as is reasonably necessary for the proper operation of its road. (84 *Atlantic Reporter* 697.) The court did not pass on the validity of the ordinance, so far as concerns stationary engines, although it was intimated that the regulation might be valid as to that class, since a similar ordinance has been upheld as to factories in a similar case. And, in a still later case, the same court held that a railroad company may be indicted for emitting smoke and gas from its locomotives in greater quantities than is required for the proper operation of the road. (87 *Atlantic Reporter* 86.)

The New York Court of Appeals has held that the use of soft coal in a factory, situated in a country district suitable for country homes, so that black smoke therefrom, great in volume and dense in quality, envelops and discolors a neighboring dwelling, causing discomfort and pecuniary loss to the occupants, is a nuisance which may be enjoined, if the use of soft coal is not essential in operating the factory and is not a reasonable use of the manufacturer's property. (McCarty vs. Natural Carbonic Gas Co., 81 *Northwestern Reporter* 549). Mr. Justice O'Brien dissented from the decision in this case on the grounds that the neighborhood in question was so sparsely settled that it might properly be called neither a residence, factory, nor business neighborhood, and that the defendant was not bound to unduly increase its fuel expense in order to secure greater comfort for plaintiff in the enjoyment of his home. He said: "Whatever we decide in this case must apply to every manufactory or manufacturing establishment in this state. It is a question of comfort on the part of the plaintiff. On the part of the defendant it certainly is a question of the right to conduct a business with good judgment and reasonable economy."

But the Pennsylvania Supreme Court has refused to enjoin the use of bituminous or semibituminous coal in an industry where it was found that such fuel was indispensable to the proper operation of defendant's iron works; deciding that any damages sustained by plaintiff could be compensated fully by a money judgment. (Richards' Appeal, 57 *Pennsylvania State Reports* 105.) The court said, however, that an injunction might be proper if the injury could be avoided by the use of other fuel equally good and available, or if smoke consumers could be installed at reasonable expense.

And, in a Massachusetts case (Downing vs. Elliott, 64 *Northwestern Reporter* 201), the Supreme Judicial Court refused to grant an injunction against the use of soft coal at an industrial plant, although it resulted in soot and cinders being deposited upon the ice of a pond, from which plaintiff derived an ice supply, where it appeared that the damage to plaintiff was insignificant as compared with that resulting from other causes, and that the use of such fuel was more economical for defendant. The court even refused to award a money judgment. The opinion in this case contains the following reasoning: "In thickly settled communities absolute purity of atmosphere is out of the question; and the more thickly settled the community is, and the more varied are the kinds of business, the more will the atmosphere be unavoidably impregnated with impurities. This is one of the inconveniences, if it is an inconvenience, which everyone who lives in a populous neighborhood must suffer." The court qualifies this statement, however, by saying that the fact that the atmosphere is already impure does not excuse one in increasing the impurity to the discomfort of others.

In a Tennessee case, the Supreme Court reversed a judgment which enjoined the owner of a smoke-stack on a power plant from permitting smoke to escape at an elevation less than that of the roof of a near-by 15-story office building. (Union Planters' Bank & Trust Co. vs. Memphis Hotel Co., 139 *Southwestern Reporter* 715.) The court held that the injunction constituted an excess of the lower court's powers as in effect requiring the stack to be raised to a height which might injuriously affect the public safety, and said: "This smoke has to escape, and there must be smoke-stacks, and whenever one building is higher than another it will suffer from the smoke issuing from the stacks of the lower, unless some means could be devised whereby all stacks could be made a uniform height, and even that would not obviate the trouble, because of the tendency of smoke to descend in damp weather, and because of downward eddies in air currents which exist in the neighborhood of high buildings."

When a property owner establishes a right to be awarded damages on account of the maintenance of a "smoke nuisance," they are to be measured according to whether the injury is merely to the enjoyment of the property or to the property itself; in the absence of injury to the property itself, the measure of damages is the diminution in the rental value caused by the maintenance of the nuisance. This depreciation must result from interference with the comfortable enjoyment of the premises, and not from the mere prejudice against the property in consequence of its proximity to the plant, for the latter depreciation cannot be said to have been caused by the injury. But when permanent injury to the property is done, the owner is entitled to recover the consequent diminution in the value of the property. (Iowa Supreme Court, McGill vs. Pintsch Compressing Co., 118 *Northwestern Reporter* 786.)

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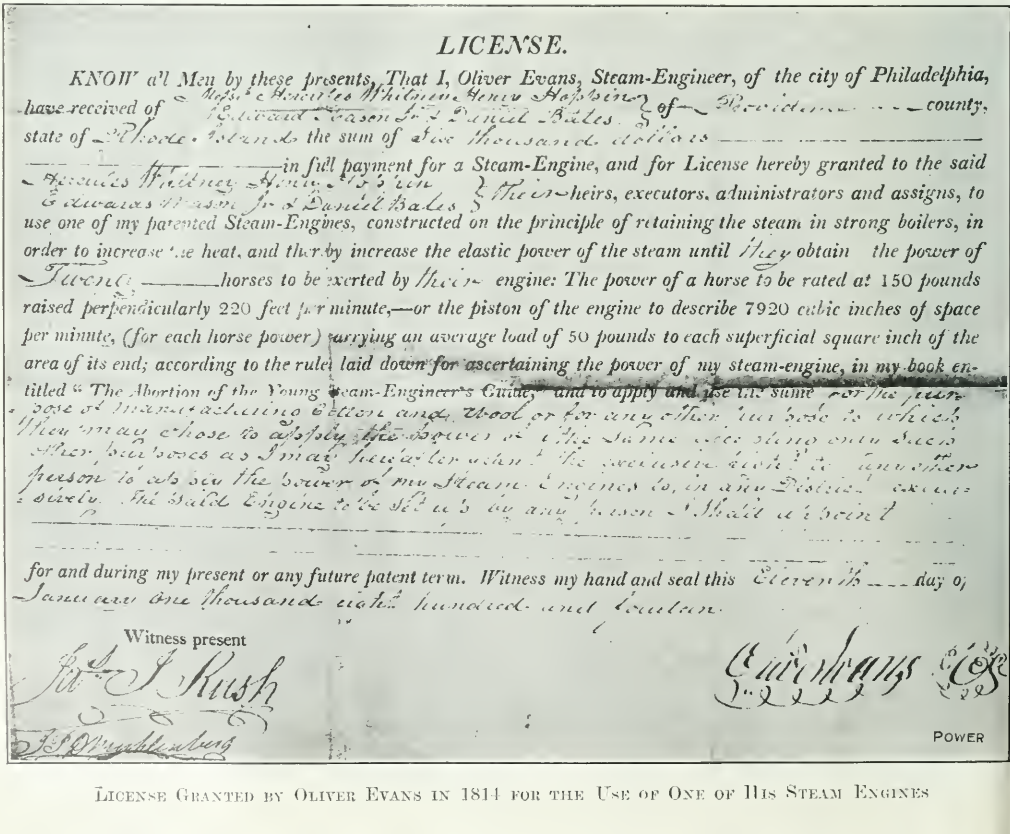
An Oliver Evans License of 1814

When John P. Farnsworth, President of the Providence Dyeing, Bleaching and Calendering Co., welcomed the recent Power Show to Providence on behalf of the Chamber of Commerce, he exhibited a license granted to the founders of his company in 1814, by Oliver Evans, authorizing the use by that company of one of Evans' patented engines, and bearing his own signature. The accompanying illustrations are reproductions of photographs of the face and reverse of this license. The company holds also the patent for the first friction calender ever made, transferred to them by the inventor, Wm. Smith, in the year 1809, the patent having been taken out in 1805, and being signed by Thos. Jefferson, President, and Jas. Matteson, Secretary of State. The first valve motions patented by Mr. Corliss were tried out on the engine in the Sabin St. plant of the same company. It was a walking beam engine with a capacity of about 150 hp.



LICENSE.

KNOW all Men by these presents, That I, Oliver Evans, Steam-Engineer, of the city of Philadelphia, have received of Mess.rs Hercules Whitney Henry Hopkins Edward Mason Jr & Daniel Bates *of* Providence *county, state of* Rhode Island *the sum of* Five thousand dollars *in full payment for a Steam-Engine, and for License hereby granted to the said* Hercules Whitney Henry Hopkins Edward Mason Jr & Daniel Bates their *heirs, executors, administrators and assigns, to use one of my patented Steam-Engines, constructed on the principle of retaining the steam in strong boilers, in order to increase the heat, and thereby increase the elastic power of the steam until* they *obtain the power of* Twenty *horses to be exerted by* their *engine: The power of a horse to be rated at 150 pounds raised perpendicularly 220 feet per minute,—or the piston of the engine to describe 7920 cubic inches of space per minute, (for each horse power) carrying an average load of 50 pounds to each superficial square inch of the area of its end; according to the rules laid down for ascertaining the power of my steam-engine, in my book entitled "The Abortion of the Young Steam-Engineer's Guide," and to apply and use the same* for the purpose of manufacturing Cotton and Wool or for any other purpose to which they may chose to apply the power of the same according only such other purposes as I may hereafter grant the exclusive right to any other person to apply the power of my Steam Engines to, in any District exclusively. The said Engine to be set up by any person I shall appoint

for and during my present or any future patent term. Witness my hand and seal this Eleventh *day of* January one thousand eight hundred and fourteen.

Witness present

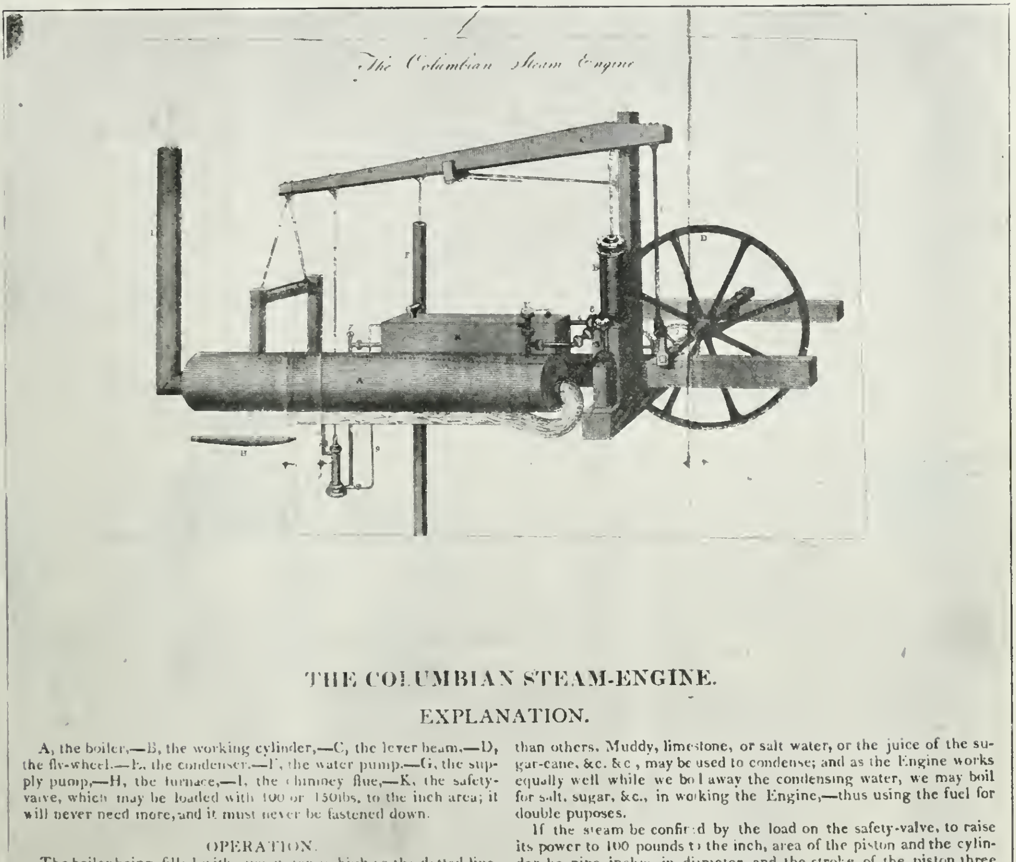
Jn. S. Rush

J. P. Muhlenberg

Oliver Evans

POWER

License Granted by Oliver Evans in 1814 for the Use of One of His Steam Engines


The Columbian Steam Engine
C
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THE COLUMBIAN STEAM-ENGINE.

EXPLANATION.

A, the boiler,—B, the working cylinder,—C, the lever beam,—D, the fly-wheel.—E, the condenser.—F, the water pump.—G, the supply pump,—H, the furnace,—I, the chimney flue,—K, the safety-valve, which may be loaded with 100 or 150lbs. to the inch area; it will never need more, and it must never be fastened down.

OPERATION.

The boiler being filled with pure water as high as the dotted line, and the fire applied, the smoke enters the center flue, which passes through the center of the water to ascend the flue I, and thus acts on a large surface.

When the steam lifts the safety-valve, it is then let into the cylinder by opening the throttle-valve, to drive the piston up and down, which, by rod 1, gives motion to the fly-wheel, and wheel 2 gives motion to a shaft, passing through the posts, to turn the spindle of the rotatory valves 3, 8, which lets the steam both off and on the cylinder at the proper time.

The steam escaping by pipe 4, curved and immersed in the water in box E, which is supplied by pump F, it is condensed, and the water formed, descends by pipe 5 into supply-pump G, and is forced into the boiler again by pipe 6.

But boiling decomposes water slowly, changing it into air incondensible. Therefore the snifting-valve 7 is necessary. This valve lifts at every puff of steam, and a small quantity of air escapes; and it shuts, and a vacuum is instantly formed, as the crank passes the dead points.

The small waste of water may be supplied by condensing part of the steam rising from the condensing water, to run down the Pipe 9, through a hole in the key of a [illegible] [illegible] parts of an inch diameter.—A small hole indeed to supply a boiler of twenty horses power.

No sediment can accumulate in the boiler, it being supplied by distilled water. Therefore it will last much longer and require less fuel than others. Muddy, limestone, or salt water, or the juice of the sugar-cane, &c. &c., may be used to condense; and as the Engine works equally well while we boil away the condensing water, we may boil for salt, sugar, &c., in working the Engine,—thus using the fuel for double puposes.

If the steam be confined by the load on the safety-valve, to raise its power to 100 pounds to the inch, area of the piston and the cylinder be nine inches in diameter, and the stroke of the piston three feet, the power will equal twenty horses hitched; and will grind 20 bushels of grain per hour, or saw 5000 feet of boards in 12 hours. If the steam be confined by 150 pounds, the power of the Engine will be equal to thirty horses, when the steam is shut off at one third of the stroke, and striking thirty-six strokes per minute.—Double strokes double the power.

The more the steam is confined, and the shorter it be shut off by the Regulator 8, the greater will be the power obtained by the fuel. For every addition of 30 degrees heat to the water doubles the power. So that doubling the heat of the water increases the power about 100 times. On these principles fuel may be lessened to one third part consumed by other engines. This Engine is not more than one fourth the weight of others; is more simple, durable, and cheap, and more suitable for every purpose; especially for propelling boats and land carriages. It requires no more water than the fuel will evaporate in steam, and this steam may be employed to warm the apartments of factories; or the condenser E could be used as a still to distil spirits; or a vat for paper making, boiler in a brewery, dye factory &c. &c.

The Patent Right now belongs one half to the Subscriber, Philadelphia; one fourth to George Evans, Pittsburg; and one fourth to Luther Stephens, Lexington, Ky. Apply to either for Engines, or for Licenses to use them.

OLIVER EVANS.

POWER

Reverse of License, Explaining Evans' Engine of One Hundred Years Ago

Temperatures within Internal-Combustion Engines

A recent article in *Zeitschrift des Vereines deutscher Ingenieure* describes some interesting experiments to determine the rapidly changing temperatures within the cylinder of an internal-combustion engine, electrical measuring instruments being used.

The thermocouple shown in Fig. 1 is of chemically pure platinum and a platinum-rhodium alloy containing 10 per cent. rhodium. The tube or body is of good quality porcelain and in order to obtain an air-tight packing between the inside of the tube and the atmosphere, two conical pieces *e* and *f* of the same material as the corresponding wires, are welded to the wires. The free ends of the wires are led so far away from the cylinder as to render negligible the effect of radiated heat and maintain their temperature at that of the room, namely 20 deg. C.

The resistance pyrometer shown in Fig. 2, with which readings were also taken, is similar in construction to the thermocouple, except that the wires are of a platinum-iridium alloy (35 per cent. iridium), and the fire end strongly resembles the filament of a tungsten lamp.

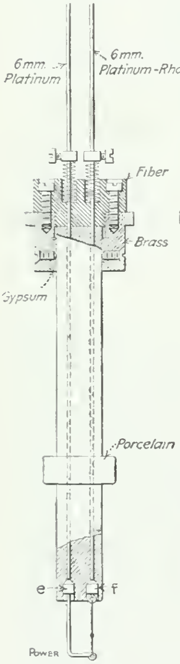

Fig. 1. Thermo Couple

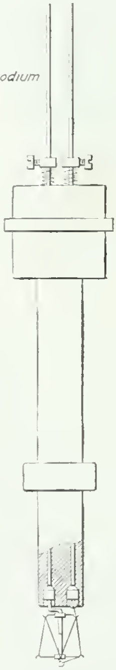

Fig. 2. Resistance Pyrometer

For measuring the electromotive force set up in the thermocouple an Einthoven string galvanometer was selected, because of its very small inertia, the moving element being a gold string having a diameter of 0.0003 inch.

A 6-hp., $3\frac{1}{8}$x$3\frac{3}{4}$-in., two-cylinder gasoline engine was selected for the test. This was placed on a special frame so as to reduce vibration when running at a normal speed of 900 r.p.m., and thus not interfere with the sensitiveness of the galvanometer. Fig. 3 shows how the thermocouple was attached to the cylinder head.

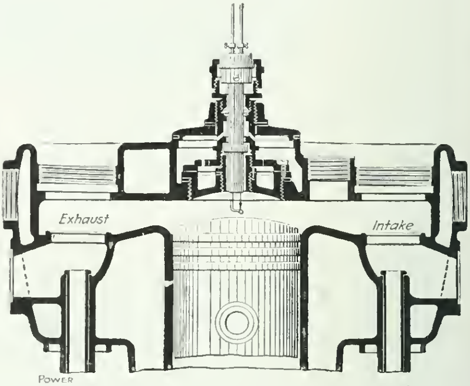

Fig. 3. Section through Cylinder Head, Showing Location of Thermocouple

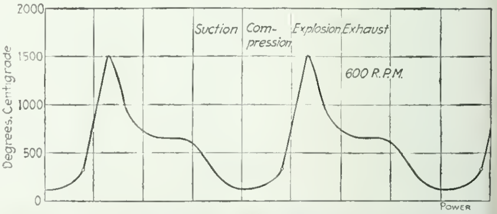

Fig. 5. Diagram Taken with Resistance Pyrometer

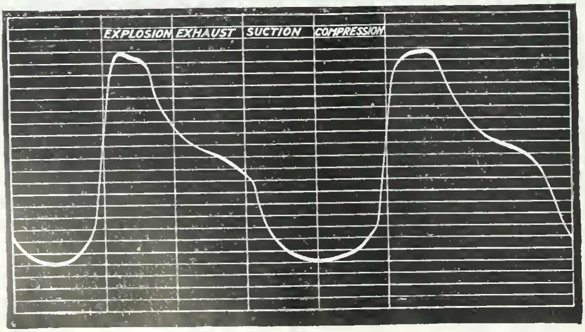

Fig. 4. Diagram with 0.03-Mm. Wire

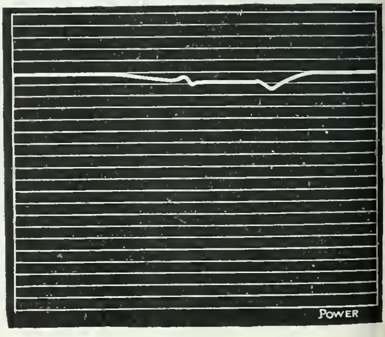

Fig. 6. Diagram with 0.6-Mm. Wire

Readings were taken with thermocouple elements of different diameters at the part exposed to the high temperatures, with a view to ascertaining which would give the best results. The results with these are shown in the following tabulation:

Diameter of Wire, Mm.	Temperature, Deg. C.	
	Highest	Lowest
0.02	1400	142
0.025	1405	142
0.03	1410	137
0.04	1292	162
0.05	1050	307
0.1	882	475
0.2	827	585
0.4	815	695
0.6	800	775

Figs. 4 and 6 are sample diagrams, the latter with a wire of 0.6 mm. diameter, which shows an approximately straight line. The temperatures corresponding to this (see table) are above the mean, although the higher temperature influences the couple only during one stroke, while the lower covers three strokes. This nearly constant temperature with the large wire was undoubtedly due to its greater mass requiring a longer time to heat up and cool off, thus making it less sensitive to very rapid temperature changes.

Reference to the table shows that with wire thicknesses of 0.02, 0.025 and 0.03 mm., practically the same high and low temperatures were recorded, which indicates that a decrease of mass within these limits has no influence upon the sensitiveness of the instrument. Fig. 5 shows a diagram taken with the resistance pyrometer. As the ignition point is clearly indicated, the temperatures corresponding to different piston positions are easily found by drawing ordinates to correspond with the four principal events in the cycle.

* *

Gravity Feed Semi-Stokers[*]

By Osborn Monnett[†]

SYNOPSIS—How smokeless results are obtained with this type of furnace. Directions for charging, cleaning and banking.

*

There is a class of equipment on the market half way between a mechanical stoker and a hand-fired furnace which can well be classed as a semi-stoker, of which there are two distinct types, the down-draft and the gravity feed. The gravity-feed furnace is essentially a dutch-oven extension built in a cast-iron frame work with an arch of firebrick and a horizontal central grate. On each side of the central grate is a short inclined grate above which are pockets for the admission of fuel. The theory of this type of furnace is to raise up the mass of fuel on the side grates with a poker or transfer bar, as the case may be, allowing the fresh fuel to gravitate behind it. Thus the fresh fuel is introduced underneath the choked portion of the fuel bed, and the volatile gases must pass through the incandescent fuel before coming out into the furnace proper. By this action it is intended to consume the volatile gases before they have an opportunity to cause smoke.

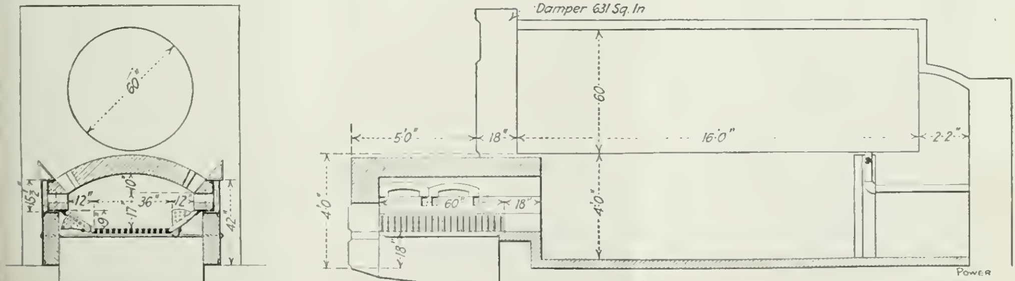

Fig. 1. McMillan Furnace under 90-Hp. Return-Tubular Boiler

A gravity-feed furnace as applied to a horizontal tubular boiler is shown in Fig. 1. The application is simple, as it is necessary to build only a bridge-wall at the front end of the boiler, leaving a plain combustion chamber extending the full length underneath. These furnaces should always be set full extension. They can be placed in a head room of from 48 in. up, and as they operate without steam jets or stoker engines, they are equally applicable to high- or low-pressure installations.

It is a simple matter to apply the gravity-feed furnace to a water-tube boiler of the horizontally baffled type shown in Fig. 2. It gives a long flame travel and, if properly handled, allows ample time for the combustion of the volatile matter before it comes in contact with the heating surface. The furnace may be used with any type of horizontally baffled boiler, but it is not advisable to apply the gravity-feed furnace to a water-tube boiler vertically baffled as smokeless results cannot be guaranteed because of the short flame travel.

With this furnace, limitations as to size come from the consideration that when the coked coal is poked off the side grates it naturally falls onto the middle one. If this middle grate is of such width that the coked coal easily covers it, then the characteristic action of the furnace will not be destroyed. If, however, the middle grate is so wide as to compel the fireman to poke green coal over to keep the grates covered, then the furnace will smoke, and it is too wide for good operating conditions. Therefore, units above 200 hp. should be used only where the conditions are carefully worked out and where it is known that the highest class of operation will be had.

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[*] Copyright, 1914, by Osborn Monnett.

[†] Smoke Inspector, city of Chicago.

Fig. 3 shows a gravity-feed furnace, with a 6-ft. 3-in. extension, correctly installed under a 230-hp. Stirling boiler. The furnace proper ends at the bridge-wall and the regular Stirling arch is as in standard hand-fired practice.

OPERATION

In operating the gravity-feed furnace, first feed in enough coal to cover the bottom of the grate and side grates. Then build a fire with kindling on top of the coal, giving the furnace plenty of air through the door, the same as with a hand-fired furnace. When the fire has ignited thoroughly and most of the volatile matter has been driven off, fill one pocket at a time, allowing an appreciable interval between the filling for the volatile matter to burn. When poking a pocket, always crack the door to take care of any excess volatile which may be distilled off. When feeding, work the coked coal carefully toward the center grate with the transfer bar or run the poker down the outside of the pocket to the inclined grate and down the inclined grate nearly to the bottom; then raise the poker up into the bed of fuel so that it will carry with it the coked mass of coal toward the center of the furnace. The green coal will fall behind the coked mass, and if the door is cracked, there will be no smoke. Always keep the pockets full of coal, but do not use the top of the furnace for coal storage. If the pockets are allowed to run empty so that when replenished the green coal falls on top of the fire, the furnace will smoke. Run with the damper wide open and regulate the draft by the ashpit doors. Poke one pocket at a time and wait for the volatile to distill off before disturbing the other pocket.

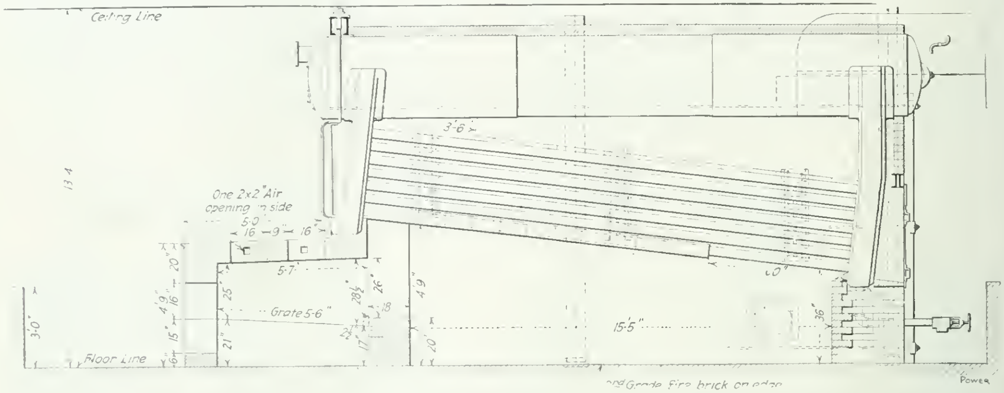


Fig. 2. Gravity-Feed Burke Furnace under 150-Hp. Water-Tube Boiler

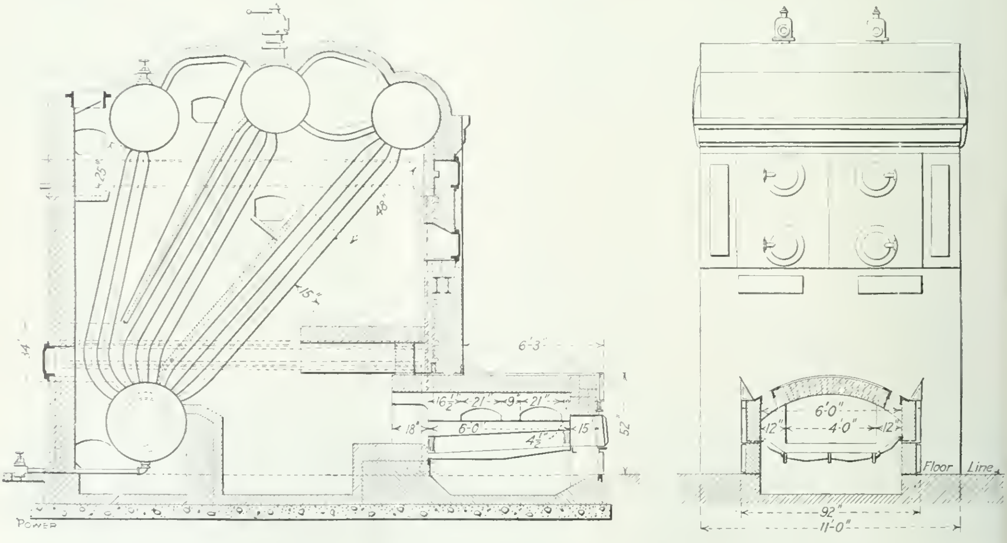


Fig. 3. Burke Furnace Installed under 230-Hp., Class A Stirling Boiler

CLEANING AND BANKING FIRES

Clean out the center grate with a hoe without disturbing the side beds of fuel. Then, using the hook, clean the clinker from under the coked portion on one side of the fire, allowing the coked coal to fall down on the center grate; in a few minutes, repeat the operation on the other side of the furnace. As these operations have to do only with coked coal, no dense smoke should be made. After spreading this coal on the center grate, leave the doors cracked and fill the pockets slowly, one at a time. When banking fires, work the coal down below the liners of the pockets and put on the covers; then close the ashpit doors and check the damper.

* *

Sizes of Motors Driving Centrifugal Pumps

By E. M. Marshall

SYNOPSIS—The calculations necessary for determining the proper size of motor to drive a centrifugal pump under given conditions of delivery and head. By the use of the chart these calculations are simplified.

*

The problem of selecting the proper size of motor-driven pump and installing it to pump water a distance at the smallest cost is one that is not always given careful consideration, hence many do not operate satisfactorily, usually failing when they are most needed. While there is plenty of pump data available, as well as motor data, there is a lack of practical information on the combination. Manufacturers sell pumps to be connected to certain types of motors and when electrical troubles come up they are glad to refer them to the maker of the motor, but are little interested in securing and tabulating for future use the nature of the trouble and the remedy. Therefore, the recommendations of a pump manufacturer, without a complete and thorough knowledge of the conditions, are likely to fall short of economical operation principally because the efficiencies of ordinary pumps are low unless operated at the conditions for which they are designed.

In what follows the writer has worked up the calculations necessary for a check on a motor-driven pump installation working back from the delivery point to the pump to determine the power requirements and the proper size of motor. The calculations refer to the installation of a motor-driven centrifugal fire pump having a capacity of 750 gallons per minute. The pump was located one mile from the storage tank and the elevation from the water to be pumped to the tank was 220 ft. The pump manufacturer recommended an 8-in. line and the following formula was used to secure the power requirements.

$$\textit{brake horsepower} = C \times H \div (4000 \times E)$$

Where C is the capacity of the pump in gallons per minute, H the total head to be pumped against, and E the pump efficiency taken at 50 per cent.

Then,

$$\textit{brake horsepower} = \frac{750 \times 220}{4000 \times 0.5} = 82.5$$

This is the method commonly used by salesmen in selling pumps, and while acting in good faith they are simply applying rule-of-thumb data found in catalogs or hand books which in every case need special interpretation and some modification and are only safe in the hands of an expert. From the calculations already given it will be seen that the value for the pump horsepower includes the suction and discharge heads but has nothing to do with the pipe friction in the 5280 ft. between the pump and the tank. It is not known how the 8-in. size of pipe for the line was arrived at; however, the following calculations will show how and where the recommendation is not practical nor economical.

The friction loss per 100 ft. of 8-in. cast-iron pipe when discharging 750 gal. of water per min. is 1.24 ft. of head; for a 10-in. pipe 0.39 ft.; and for a 12-in., 0.17 ft. The loss of head due to friction of the 5280-ft. line for the different sizes of pipe is as follows:

Size of pipe..............	8 in.	10 in.	12 in.
Loss of head.............	65.4 ft.	20.6 ft.	8.9 ft.
Saving with 10-in. and 12-in. pipes...............	..	44.2 ft.	55.7 ft.

The effect of the loss of head on the size of motor is as follows:

For an 8-in. line:

$$\textit{brake horsepower} = \frac{750 \times (220 + 65.4)}{4000 \times 0.50} = 107.0$$

For a 10-in. line:

$$\textit{brake horsepower} = \frac{750 \times (220 + 20.6)}{4000 \times 0.50} = 90.0$$

For a 12-in. line:

$$\textit{brake horsepower} = \frac{750 \times (220 + 8.9)}{4000 \times 0.50} = 85.0$$

From these calculations it is evident that a motor of 82.5 horsepower as calculated by the first formula and the use of an 8-in. pipe would cause the motor to carry an overload of not less than 30 per cent., and as the pump would be operated at full capacity when operated at all, such a demand on the motor could not have been performed without trouble for any length of time. Even with the 12-in. pipe line the motor would be loaded up to its capacity. In these calculations, an efficiency of 50 per cent. has been assumed which is somewhat less than can be expected of the best designs of pumps. However, this is not too great a factor of safety, as far as motor selection is concerned, for it is impossible to secure commercial sizes of motors that correspond exactly to the calculations made. For instance, as shown above for the different sizes of pipe line, a 100-horsepower motor will be required for the 8-in. line, and the 10-in. line and a 75-horsepower for the 12-in. line, which will just about place the pumps on a 60 per cent. efficiency basis.

As to whether or not the additional cost of pipe for the larger sizes will be economical as to operation, the following calculations show:

Cost of 75-hp. motor for 12-in. line......................	$514
Cost of 100-hp. motor for 8-in line..............	654
Cost of pipe f.o.b. factory at $20 per ton:	
8-in. cast pipe at 48 lb. per ft. or 127 tons..	2540
12-in. cast pipe at 82 lb. per ft. or 216 tons......... ..	4320

The cost of motor operation at 2c. per kilowatt-hour is as follows:

For a 100-hp. motor:

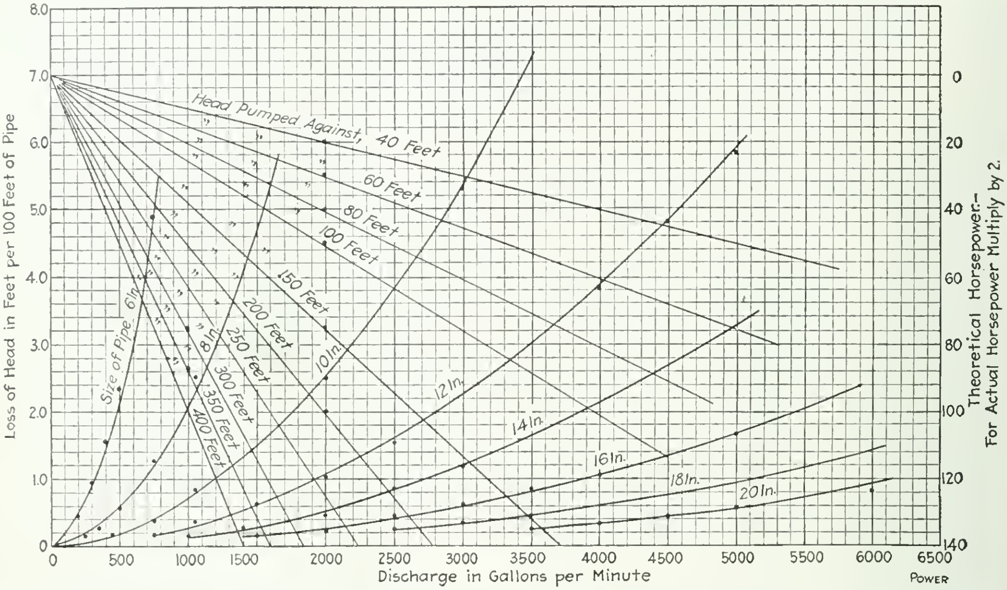
$$\frac{100 \times 746 \times 0.02}{1000} = \$1.49 \textit{ per hour}$$

For a 75-hp. motor:

$$\frac{75 \times 746 \times 0.02}{1000} = \$1.12 \textit{ per hour}$$

The demand on the pump was 250,000 gallons per day, which required it to operate

$$\frac{250{,}000}{750 \times 60} = 5.5 \textit{ hours per day}$$



CURVES, SHOWING LOSS OF HEAD DUE TO FRICTION OF STRAIGHT AND SMOOTH CAST-IRON PIPE; ALSO THEORETICAL HORSEPOWER FOR DRIVING PUMPS

Then the annual cost of pumping is:

For a 75-hp. motor = 5.5 × 365 × \$1.12 = \$2248
For a 100-hp.-motor = 5.5 × 365 × 1.49 = 2936

Yearly difference in cost of operation..	\$688
The extra cost of the 12-in. pipe (4320 — 2540) = \$1780	
Saving in cost of the motor in favor of the 12-in. pipe = \$140	
Extra cost of pipe less saving on motor...............	\$1640
Five years' saving in cost of motor operation........	3440
Five years' interest at 6 per cent. on extra investment plus the investment................................	2132
Total saving in five years in favor of 12-in. pipe..	\$1308

Besides this saving, better operation is secured with less trouble and fewer interruptions, worth perhaps in case of fire, many times this amount.

Many of the calculations given in the foregoing discussion can be avoided by use of the curves in the accompanying chart showing loss of head in feet due to friction for straight, smooth cast-iron pipe and the theoretical horsepower required to drive pumps. To use this set of curves proceed as follows: Suppose it is required to know the size of motor to pump 750 gallons of water per minute using a 10-in. pipe and pumping 5280 ft. against 220-ft. head. Finding 750 on the horizontal line of the curve as the discharge per minute, follow vertically to the curve for 10-in. pipe and read a loss of head of nearly 0.4 ft. per 100 ft. of line. Since the length of line is 5280 ft. the total loss of head is then 0.4 × 5280 ÷ 100 = 21 ft. Adding this to 220 ft. of vertical head, the total head to be pumped against is then 220 + 21 = 241 ft. Again finding 750 gallons per minute discharge on the bottom of the curve sheet run up vertically to the straight line showing 250 ft. head and then directly across to the right reading about 46 horsepower, or the theoretical power required. This figure does not take into account the efficiency of the pump which can be safely taken as 50 per cent. Then to get the actual size of motor, the horsepower as shown, namely 46, must be divided by 0.5, giving 92 as the horsepower required.

⁂

An Omission

Owing to an oversight the accompanying table was omitted from the article entitled "Department No. 8 and Special Furnaces," by Osborn Monnett, on page 166 of the August 4, 1914 issue.

DIMENSIONS FOR FIG. 1
(All Dimensions in Inches except Column B which is in Feet)

A	B	C	D	E	F	G	H	I	J	K	L	M
42	12	28	19	42	42	22	16	3½	16½	18	9	8
42	14	28	19	48	42	22	16	4	15	18	9	8
48	12	30	20	42	48	24	18	3½	18	18	9	8
48	14	30	20	48	48	24	18	4	16½	18	9	8
48	16	30	20	54	48	24	18	4½	15	18	9	8
54	14	32	22	48	54	24	18	4	16½	18	13½	8
54	16	32	22	54	54	21	18	4½	15½	18	13½	8
60	16	34	22	60	60	26	18	5	17	22½	13½	8
60	18	34	22	66	60	26	18	5½	15½	22½	13½	8
66	16	34	24	60	66	28	18	5	18½	22½	13½	8
66	18	34	24	66	64	28	18	5½	17	22½	13½	8
72	16	36	24	66	72	30	20	5½	18½	22½	13½	8
72	18	36	21	72	72	30	20	6	17½	22½	13½	8
78	18	38	26	72	78	32	21	6	19	26	18	8
78	20	38	26	78	78	32	21	6½	17½	26	18	8
84	18	38	26	72	84	32	21	6	20	26	18	8
84	20	38	26	78	84	32	21	6½	18½	26	18	8

Note:—Dimensions in the above table apply only for the ordinary conditions and are subject to revision for unusual conditions.

Note:—First grade fire brick to be used throughout with the exception of the combustion chamber floor and the side walls of the chamber back from a point one ft. behind the rear face of the wing-walls. Wing-walls to be bonded into side walls. No air space to be left in setting walls. Fire doors must provide for special air admission of an area equal to 4 sq.in. for each sq.ft. of grate surface.

⁂

Missouri Coal Production in 1913—The production of coal in Missouri in 1913 was 4,318,125 short tons, valued at \$7,468,308, a decrease compared with 1912 of 20,731 tons in quantity and of \$165,556 in value. With the exception of 1912, however, the output in 1913 was the largest in the history of the state.

Editorials

Does "Safety First" Legislation Handicap the Steam Plant?

A gasoline-engine advertisement in a popular magazine recounts the experience of a contractor who had successfully used the engine advertised upon some contracting work.

> First he used steam. But steam meant a licensed engineer and fireman. It wasn't sufficiently portable and elastic. He had to keep several types of boilers to conform with different state and city ordinances.

Whereat numerous engineers and sundry manufacturers of boilers, engines and steam apparatus think they see a big beam of light. All this Safety First Legislation requiring a man who sets up a boiler in a crowded district to put a competent and reliable man in charge of it, requiring a boiler to be correctly designed and honestly built of suitable material, forbidding the pollution of the air in which thousands must live, by unnecessary fumes and smoke, all this beneficent legislation which other countries have adopted with a signal decrease of the loss of life and property and a marked betterment of the conditions in industrial neighborhoods must be opposed and rescinded or the internal-combustion engine and central station will take advantage of the hardships which it imposes to put us out of business.

How much of a hardship would it be for a contractor or other employer to hire a licensed engineer or fireman. He might have to pay a lesser daily wage to a laborer who could not satisfy an inspector that he was a safe and competent man for the place (and that is all that an inspector can require of a man), but if everybody had to hire licensed men he would be at no competitive disadvantage as between certified and uncertified labor, and as for skill, we have never found that less skill was required to run an internal-combustion than a steam engine. Insurance and fire-department regulations regarding the storage of oil and gasoline are likely to prove more onerous, within centers of population, than the legislation referred to.

The disadvantage which arises from lack of uniformity in the boiler laws of various states and cities is a real one, not only to the user but to the maker of boilers. He cannot make boilers up for stock and is obliged to carry all kinds of material or to buy in small lots for each order. This does not mean that the interests of the boiler manufacturers can be best served by discouraging the passing of any more such laws and the enforcement of those already on the books. Their real interest lies in having uniform laws which unify and standardize the work and material and put the man who gets the contract by skimping the material and slighting the work out of the running.

The best interest of good engineers and good boiler makers lies in forwarding, not in opposing the proposed uniform legislation for the inspection of boilers and the examination and licensing of engineers.

Avoiding Irregularities in Station Design

To many engineers the design of a generating station on the so called unit system appears cut and dried practice. Doubtless systematization can be carried too far in the treatment of engineering questions bearing upon power development, but experience shows that departures from uniformity in equipment arrangement sometimes lead to troublesome complications, particularly where such changes from regularity are made to reduce first cost. Thus, in a hydro-electric station of four units, the exciter turbines were arranged to receive their water-supply from the penstock of one unit, the other three penstocks being connected to their respective wheels without any auxiliary piping. In each penstock a Venturi meter recorded the flow of water in the usual way.

Since the meter in one penstock recorded the flow through the corresponding generating unit and the exciter turbine carrying the plant at any particular time, it was impracticable accurately to determine the rate of flow through the main turbine. To estimate this it was necessary to operate two turbines and their generators at as nearly equal load as possible, one of the penstocks supplying the exciter turbine, which ran at practically constant gate opening. Curves were plotted in millions of gallons per 24 hr. as ordinates and gate openings as abscissas, and it was assumed that since these turbine units were of the same rating and design, the difference in ordinates of these curves for a particular gate opening would give the rate of flow through the exciter. It was not found feasible to check this method closer than 300,000 gal. in 24 hr., but this was within 4 per cent. of the total water consumption of the exciter turbines.

This approximate method of determining the water consumption of the turbine whose penstock also supplied the exciter would not have been necessary had the unit plan of station design been followed in which each exciter wheel has its own independent pipe connection with the forebay. The first cost probably would have been increased somewhat, but not enough to overcome the advantage of being able to read the water consumption rate and total flow with 98 per cent. accuracy from, say, half load to about 25 per cent. overload on each of the main turbines.

More and more the accurate measurement of water in hydro-electric stations is receiving the deserved attention of engineers; in many cases it is as important as the measurement of fuel in steam plants, and where meters such as the Venturi are installed to check the performance of the various station units and to forestall falling off in operating efficiency or to control more closely the reservoir and discharge conditions, it is a pity not to make the best possible installation of equipment on the station-unit principle and thus obtain the best results of a far-sighted investment.

Neatness

The owner of a fairly prosperous shop was asked not long ago why he did not keep things picked up and swept up better. His reply was that if he did his customers would think he had nothing else to do and would take their work elsewhere. Whether this is false philosophy or not, it is a fact that an engine room is apt to be the most presentable part of a manufacturing plant. As an index of good management it is the exact opposite of the idea expressed by this particular shop owner. The less an engineer has to do the greater his value. If he is continually fixing up leaky couplings and packing piston rods, it is an indication that he is doing something that he should have done some time before or else that he tries to economize on cheap packing that is not worth using.

An engineer who has a Corliss compound in a nice light room with rubber matting all around and a handsome switchboard to show his friends feels compelled to keep his plant in nicer shape than his wife does her parlor. The other poor fellow who finds a broken down cripple of a slide-valve engine in a dark corner fenced off from the rest of the shop by nothing more substantial than a pile of scrap castings, has a right to an attack of the blues. He thinks he is not likely to be found there by someone who wants a man in one of the nice plants and he is apt to let things go as he finds them and trust to luck to find a better job. That is where he is mistaken. A neat, clean engine, running smoothly and keeping at it every day will attract more attention among such surroundings than it will where such things are expected. There may not be many mill or shop owners coming around to visit the plant, but salesmen whose business it is to know every plant will come and they can do nothing better for themselves than to tip off an owner as to where a good engineer is to be found. One can never go far enough off to get out of sight and hearing of men who might be friends.

An engineer who keeps things clean and does nothing else is a faker and no more. Neatness must be a by-product of ability or it is worthless.

⁂

Attention of Firemen

Considerable space in Power is devoted to advice to engineers to improve their condition and qualify for higher salaries, shorter hours of labor, etc. This advice is good and should be appreciated, but how about the fireman?

Seldom is any disposition shown by the men who are employed in the fireroom to study to improve their condition, or to follow instructions when the work or methods were not entirely in accord with their hard and set way of firing. Still, you will hear them complain about the hard work, the small pay and the long hours. The fireman will tell you very quickly how many pounds of coal he wheeled in and burned under the boilers, how many barrows of clinkers and ashes he wheeled out during his watch. He will tell you all this in a way to impress you with his ability to burn coal and clean fires, but did you ever hear one say anything about how much water he evaporated per pound of coal during his watch, or that he found that, with the especial grade of coal he was burning, a fire maintained at a certain thickness gave the best results, or that he was able to maintain constant steam pressure by watching his water gage, or better results were obtained by him because, instead of filling the furnace with coal clear up to the door and sitting down and waiting for it to burn, he puts the coal in in small quantities and as regularly as required, keeping the furnace door closed as much as possible, and only by systematic firing can this be done.

The fireman, as a rule, is a hard-worked man and most fire rooms are not very pleasant. They are hot and dusty, accommodations for washing and toilets are poor and frequently the fireman has to go home dirty, which does not cause him to like his job any too well. The average fireman does not realize the important position he fills in the plant. Generally he is in charge of boilers located in buildings costing thousands of dollars, in which are employed a large number of people. Unless he is alert and onto the job, damage might be done, or the works closed down for want of proper and efficient attention to duty.

Better conditions would exist if there were more coöperation between the engineer and fireman. The fireman should improve himself by studying conditions of the boilers and furnaces he is working in order to improve and demonstrate his ability to his employer and show that his aim is to get all that is possible out of his plant at the least possible cost by constant attention to every detail where waste might exist. The employer, on the other hand, should study the comfort of the fireman and give him decent and proper facilities so that he may go home clean. He should show that he is interested in him and that he expects the fireman to study his interest in return. As soon as the employer realizes that, to economically operate his plant, he must look to the interest of his men, and the employee in the fireroom realizes that to better his condition he must improve by close application to study in his chosen line and by giving his employer the best there is in him, the better it will be for both.

⁂

Bumped Heads

Power has been charged with putting undue stress upon the liability of bumped heads of large size to fail from the effect of repeated flexure about the line where the radius of curvature changes. Since our warning was sounded another disastrous explosion has happened from this cause and the Massachusetts Board of Boiler Rules proposes to stiffen up its requirements with regard to bumped heads by increasing the factor in its formula from 5 to $8\frac{1}{3}$ and making the radius of the short curve three or four times the thickness of the material. The British Board of Trade restricts the use of bumped heads to drums of 48 inches and under.

⁂

If you do not record the coal consumption and energy output, you can never know how much steam can leak through a small hole.

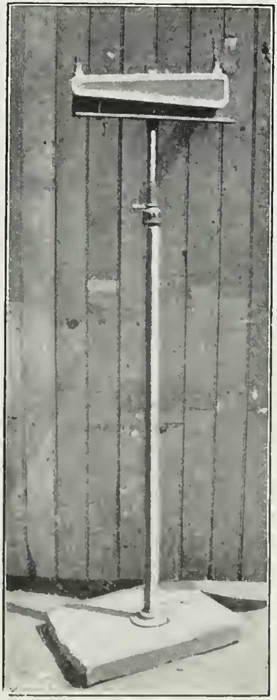
⁂

Latest bulletin of the Mellon Institute says Pittsburgh should be the greatest center in the world for combustion engineers. But who wants to assume responsibilit for the job of making Pittsburgh smokeless?

Correspondence

Portable Draft Gage

This draft-gage support is useful when taking readings at different points in boiler settings.



Gage Stand

The base is of 2-in. board about a foot square, to which is fastened a floor flange screwed on a 1-in. pipe some 4 ft. long. A 1x½-in. reducing coupling is reamed out to allow a ½-in. pipe to slip through it and is drilled and tapped for a setscrew, as shown.

A ½-in. pipe 3 ft. long is flattened for 6 in. and drilled to receive two bolts which hold a 2-in. angle-iron leveling support. The flattened pipe extends high enough above the angle iron to receive the bolt which holds the draft gage in place. There is a setscrew at each end of the angle iron for leveling the draft gage. By means of these adjustments the instrument may be set and leveled quickly.

Cecil Cahert.

Columbus, Ohio.

⁂

Operating Underfeed Stokers

J. C. Hawkins' difficulties due to the formation of clinkers on the side walls of boiler furnaces and the various methods he has employed to prevent this clinkering are interesting, yet it is hardly surprising that he was not entirely successful in his efforts. In the first place, none of the bricks or other materials suitable for boiler-furnace construction will prevent the adherence and building up of clinkers. Furthermore, his efforts were not directed against the formation of clinker, but rather against its sticking to the brickwork.

A very simple remedy for troubles of this kind is the use of steam jets. These jets should be so located that they will play upon the side walls where the clinker formation occurs. Only a small amount of steam is required and the apparatus for applying it is quite simple.

A piece of ½- or ⅝-in. pipe having a longitudinal row of small orifices and applied to each side wall, on the inside, of course, will do. This pipe may be easily inserted through the furnace front and fastened to the side wall. The inserted end should be capped, whereas the other end may be connected either with the steam line or to the boiler itself, as may be most convenient. The length of the pipe is governed by local conditions; that is, by the length of clinker formation on the walls.

It is rather amusing to note Mr. Hawkins' comments on the smoke question and his way of keeping within the law. The emission of smoke from a stack at night is just as much an infraction of the law as during the day. Mr. Hawkins merely takes advantage of the smoke inspector's inability to catch him at it. A better result, so far as the smoke problems is concerned, might be obtained if the fires are cleaned oftener, so that they will not get into bad condition. Moreover, there should be no necessity for "barring" a fire when an underfeed stoker is used, and this practice can be almost entirely eliminated by exercising care and watchfulness. It seems to be a difficult matter to prevent firemen from "working" the fires unnecessarily. There must be some fascination about it.

Everard Brown.

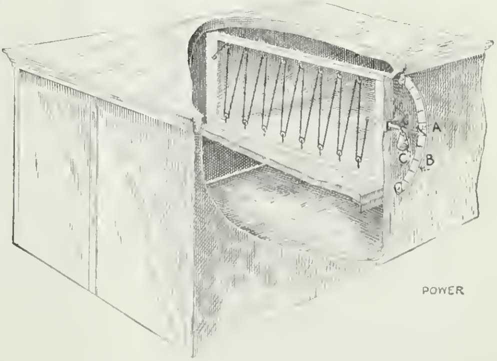
Pittsburgh, Penn.

⁂

Hygrometer Actuated by Hemp Cord

Having experienced much difficulty with the various types of hygrometers, I made the instrument shown in the illustration.

In the center of the sheet-iron box a frame was fitted up with eight 1-inch pulleys on top and bottom. Through these was drawn a cord. As hemp cord shortens when damp and lengthens in drying, this means was used to work the arm of the indicator *A*. This operates in a semi-circular form upon the arch *B*, graduated as shown; the weight *C* gives tension to the line on the pulleys.



Hempcord Hygrometer

The movement of indicator *A* accurately shows the state of the air from very wet running downward to very dry.

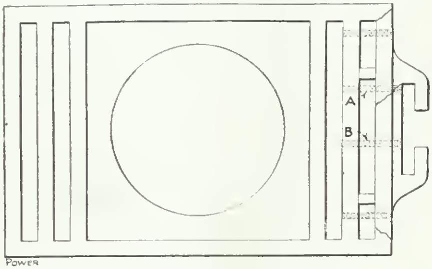
J. A. Lucas.

New York City.

Repairing a Broken Slide Valve

Speed is the principal factor in emergency cases and every minute saved on a break-down job means dollars to the owner. The valve of a 100-hp. engine came into the shop broken as shown. This accident caused a large plant to shut down until a rush repair job could carry it on temporarily and a new valve could be put in.

On being turned over to the repair man, he said that the valve would be ready for use in a short time. He was laughed at, but told to go ahead.



Repair Completed

The valve was put on a surface plate and the broken pieces carefully clamped in place and drilled. Machine screws were put in as shown, using spacers at *A* and *B*, thus making the valve as serviceable as it was originally. The repair was finished in about one-half the time it was expected to take.

Fred E. Laird.

Yonkers, N. Y.

⁂

Improving a Vacuum Heating System

A vacuum heating system is undoubtedly a fine thing when properly installed and operated, or it may be a source of great annoyance to an operating engineer. The plant in which I am employed is considered the finest for its size in the Northwest. It has a vacuum heating system as part of its equipment.

On going over the plant for the first time, I found that the vacuum pump, instead of moving at a slow, steady gait, was making about 80 strokes per minute. The night engineer remarked that the previous chief examined the valves about once each week, but never could overcome its nervousness.

The next day I gave the water end a thorough overhauling; the valves were in good condition, but the water piston was minus even the slightest hint of packing. This being remedied, the pump settled down to work in a normal manner. This was during moderate weather and with atmospheric pressure on the heating system. When cold weather came and we had a 4-in. vacuum on the system, the pump suffered a relapse. Inspection of the valves and packing failed to show the cause.

Upon looking over the piping, I found that the pump discharged into an overhead tank which was vented to the atmosphere. From this tank the returns flowed to the open heater through a 4-in. line. As the return water was insufficient to keep the line to the heater sealed for the greater part of the time, the air thereby admitted to the heater had to be handled by the pump. The defect was overcome by putting a 6-ft. water seal in the line from the tank to the heater, and there was a marked reduction in speed.

However, there still seemed room for improvement, and my suspicion fell on the line which trapped the oil separator. This line, on being disconnected on the discharge side of the trap, proved the suspicion was well founded. There would be a suction of air into the line for perhaps a minute, and then a long discharge of a full stream of oily water. A water seal was also inserted in this line, the trap removed and the line left open for a few days to watch the result. After blowing down the boilers, a full-sized stream of muddy water issued from this pipe, and there was revealed another peculiar condition.

The blowoff line leads into a blowoff tank and the drain line from the back pressure valve discharges into the same tank. Blowoff water from the boiler had backed up this drain line into the exhaust line and had flowed back until the separator had caught it and shot it through the separator drain. It was easy to see that air could enter where water could go when there was a 4-in. vacuum to entice it. So a check valve was placed in the drain line of the back pressure valve and at last the pump got down to something like normal speed.

E. S. Fitz.

St. Paul, Minn.

⁂

Cost of Operating a Vacuum Ash-Handling System*

Mr. Sandstrom obviously refers to that type of conveyor in which a current of air is maintained by a compressor, positive blower or fan. His figures seem to be deduced from experience with one conveyor only, and improperly designed, as is indicated by the unnecessarily large motor, the excessive wear, and the fact that the conveyor was, as he says, abandoned. Scores of conveyors of this general type are in use, and only a few of the earlier installations have not proved economically efficient. A comparative survey of the field, noting the character of the plants in which these conveyors are successfully operated and the names of the engineers who have repeatedly specified them, would prove that the failure mentioned by Mr. Sandstrom is the exception rather than the rule.

The figures of operation cost as deduced are fairly close to the actual cost, the errors tending to balance one another. The items are discussed under the heads of power, labor, interest and depreciation. I criticize them as follows: A conveyor having 7 tons capacity per hour would require a motor of from 15 to 30 hp., never exceeding the latter unless of great length or having an unusual number of turns. The cost of electrical power varies with the locality and the conditions, but 5c. per ton is a fair average figure.

One man can easily feed 7 tons of ashes an hour to a conveyor under ordinary conditions. In many cases, the hoppers are under the stoker hoppers, thus minimizing this labor. In most plants as small as the one under consideration, no extra labor is required as the regular fireman feeds the ashes to the conveyor, working a few minutes at a time at intervals during the day. One-half of Mr. Sandstrom's figure, or 2.8c. per ton, is ample.

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*See also April 7, July 7, Sept. 8, 1914, issues.

In estimating the cost of complete installation, Mr. Sandstrom omits the motor and exhauster, which is more than fair to the conveyor manufacturer. A conveyor for such a plant as he describes would cost not less than $3500, and with a large tank, under some conditions, might reach $4500, including trenches, floor, plates, etc. Assuming as an average $4000, the interest amounts to 7.6c. per ton.

Depreciation is the cost item which depends most largely upon the proper design, care and operation of a conveyor. Mr. Sandstrom's figure shows a depreciation of $400 per annum in the plant. I am familiar with a conveyor, built about eight years ago, where the repairs cost less than $15 per year. The motor is 25 hp. and the amount of ashes handled considerably exceeds 8.64 tons per day. The tank, although unlined, has never been repaired, but is painted occasionally.

Another conveyor, in operation over four years, removes the ashes from ten 500-hp. boilers; it has a 30-hp. motor. The repairs, according to the user, have cost considerably less than $25 per annum. The conveyor has never been out of commission, and the engineer has since specified another conveyor which has been installed and is operating successfully.

A large conveyor, of 18 tons capacity per hour, has been in operation for more than four years, handling from 40 to 50 tons per day at an annual cost for repairs of less than $50. This shows a cost under ½c. per ton of ashes handled.

A study of the records of a large number of plants shows that repairs vary from $10 to $300 per annum; cost of plants, from $3500 to $10,000; ashes handled per year, from 3000 to 20,000 tons. It is interesting to note that the highest repairs cost is frequently in smaller plants, probably because, where the amount of ashes is large, the removal is of sufficient importance to secure supervision of the conveyor.

In arriving at the cost of repairs, records from many plants show that $150 per annum is more than liberal for a plant of the size and capacity mentioned by Mr. Sandstrom. This amounts to 4.7c. per ton handled. The total cost as taken from the records of many plants, is as follows: Power, 5c.; interest, 7.6c.; labor, 2.8c.; depreciation, 4.7c.; cost per ton, 20.1c.

It is not my purpose to establish a fixed price per ton for ashes handled, as this will vary through wide limits with varying conditions. A cost of 25c. per ton for taking ashes hot from the pits and placing them quenched in cars or carts outside the boiler room is not excessive where the total amount is small. Anyone who thinks he does it for less by the use of wheelbarrows, industrial cars, skip hoists or mechanical conveyors, probably does not include all the items which enter into the cost.

W. W. Ricker.

New York, N. Y.

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Comparing Plant Efficiencies

As I have long recognized the fallacy of speaking of fuel in terms of weight and also comparing plants on a basis of pounds of coal per kilowatt-hour generated, I was much pleased with the article by Mr. Smith in the Aug. 11 issue on "Comparing Power Plant Efficiencies."

Our coal is a low-grade bituminous, mined from a seam about 4 ft. thick. The mine and also the power plant are municipally owned and operated, Lethbridge being the only city in western Canada owning and operating a civic mine. It is situated about 2000 ft. from the plant, the coal being hauled in small cars and dumped into a receiving hopper, thence through a crusher and conveyor to the bunkers, and from there it is fed through spouts to the chain-grate stokers. The proximate analysis is as follows:

Moisture	6.55%
Volatile	39.32%
Fixed Carbon	32.98%
Ash	21.15%
Sulphur	1.21%
B.t.u.	9718

The coal as fired is run-of-mine, which accounts for the large percentage of ash, and is about the same grade as the "Illinois" coal used in plant No. 3 in the article mentioned. It is interesting to compare our average for seven months with their average for six months.

B.t.u.	Kw.-Hr.	Lb. Coal per Kw.-Hr.	B.t.u. per Kw.-Hr.	Kw.-Hr. per Million B.t.u.
LETHBRIDGE PLANT				
9718	283,585	5.34	51,115	19.76
PLANT NO. 3				
9639	991.780	5.42	52,242	19.125

For an installation with an output of approximately one-third that of plant No. 3, this is a fairly good showing.

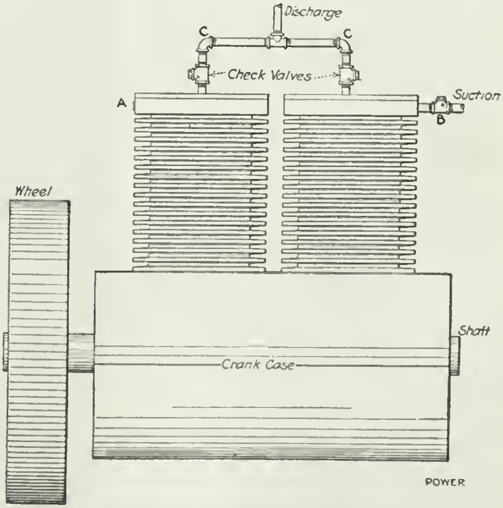
Arthur Reid,
Commissioner Public Utilities.

Lethbridge, Can.

⁂

Air Compressor Made from a Gas Engine

In our plant a recent change made it necessary to have compressed air at a pressure of 40 lb. or more. As it was something of an experiment, I could not recommend purchasing a new air compressor, so I decided to make a compressor out of an old two-cylinder, air-cooled, marine-type gas engine which was not to be used as an engine again.



Gas Engine Used as an Air Compressor

This engine had a closed crank case and a wheel on one end of the shaft. The spark plugs being set in as at *A*, it was only necessary to ream out and tap these holes to ¾ in. Into these holes I screwed a close nipple with a check valve, as at *B*, for the suction valves.

The head plates were drilled and tapped for half-inch nipples having check valves for discharge valves. The two checks in the heads were then piped together and the compressor was ready to run. It has operated with excellent results, carrying 50 to 80 lb. pressure, nine hours per day at a speed of 90 r.p.m. The total cost of the change was about $6.

A. D. PALMER.

Dorchester, Mass.

Explosion in Air Compressor

On page 72, July 14, Mr. Oerlichs does not state the air pressure used. If it is high, say, 150 lb., or even 100, his trouble should not have been unexpected from the amount of oil used. At present, I have no air compressors, but I intend to try lubricating with a mixture of soapy water and graphite, fed by a pump lubricator fitted with a check valve having a spring of sufficient strength to prevent the compressor suction from drawing in the mixture. Of course, lubricating with such a mixture will necessitate cleaning out the receiver occasionally, but it will certainly remove the danger of an explosion.

E. R. PEARCE.

Rochdale, England.

Result of Taking Chances

On Saturday, July 11, a boiler accident occurred at the Taugh Oakes mine, Swastaka, as a result of which one man was killed and another badly scalded. It appears that the outside source of electric power was cut off, and the mine started up its own steam plant. Some of the tubes were leaking so repairs were begun. Finally there was one tube short of enough to finish the replacements, so a through rod was put in with two ordinary cast-iron washers with gaskets on the tube plates, the nuts were tightened up and steam raised to 120 lb. pressure. Soon after, the joint in the firebox began to leak badly and the master mechanic went to the smoke box end, to tighten up on the rod, when the nut on the firebox end stripped with the disastrous results as stated.

It seems strange that men will take such chances with pressure like that after so many accidents have happened in the past. The tube will have to be put in after the accident, why not before?

J. B. HILLIARD.

Haileybury, Ont., Canada.

Machinery Designing vs. Repairing Facilities

My experience corroborates that of Edwin W. Creed, on page 64, July 14. I am running an engine the main body of which is cast to form a hood over the stuffing-box and forward so far that it is a long reach to get at the stuffing-box; the ends of the guide bars extend to within ⅝ in. of the gland bolts. The piston rod cannot be packed when the engine is hot, and after the nuts are taken off the gland must be pulled back and turned quarter way around to get it back between the guides; the packing must be put in and the gland and nuts put back with one hand, as there is not enough room to get both hands in.

In order to adjust the bottom guide bars, the connecting-rod must be disconnected at both ends, the piston rod taken out of the crosshead, the top guide bars taken off and the crosshead lifted out. It now takes two men one day to do the job, whereas one man could do it in half an hour if the engine were properly designed. If the crosshead brasses must be examined, disconnect the crank end of the rod and turn it straight up; take out the two bolts and the key holding the strap, and take out the brasses; reverse this order to get them all back again.

If I had been in Mr. Creed's place, I would have held up the job and insisted that the piping be done correctly.

A. A. BLANCHARD.

Oxford, N. J.

Graphite in a Mine Boiler

One boiler was a water-tube of 125 hp. and the other a tubular of about 100 hp.; both were using mine water and had at least ¼ in. of scale on the inside of the tubes and on the sheets in the drums. In some places the scale was ⅜ in. thick.

I decided to try graphite, but was doubtful of results; we put it in freely with the feed water. I opened the boilers at the end of one week, and although the graphite had no apparent effect, we still kept on using it. I opened the boilers again in 30 days and found that the scale was cracking off in places. At the end of two months our boilers were cleaner than they had been in ten years, and I believe at present they are practically free from scale.

We took scale out of the drums in sheets, some as large as 18 in. square. I found that the scale did not drop off much of its own accord except in the tubes, but as soon as it was struck with the scaling hammer it came off in large pieces.

A. S. TIDMAN.

Yonkers, N. Y.

Quick-Closing Throttles

Reading the account of an accident to a compressor on page 112, July 21, makes me wonder why engineers persist in putting the wheels of throttle valves directly in line with flywheels, and why a quick-closing throttle is not used. Double butterfly valves are a success as throttles on marine engines against any pressure, and they work easily. In this case, it is reported that the valve turned hard; I presume that it would take at least 12 turns to close it.

By using quick-closing throttles on all engines so located that they can be handled without the operator standing in line with a flywheel, many bad accidents could be avoided.

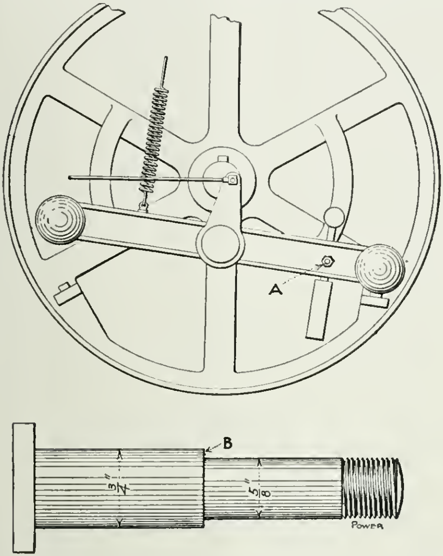
One way of lubricating a hard-closing throttle is to introduce the cylinder lubrication above it. In this way the oil will come in contact with the packing and keep it soft for a much longer time.

DAVID A. HUMPHREY.

Detroit, Mich.

Trouble with Inertia Governor

Upon taking charge of a plant, I found the governor on a 16x16-in. engine extremely sluggish. The trouble was finally located in the dashpot lever bolt *A*. The large part *B* of the bolt was not long enough by 1/8 of an inch, causing the lever to bind on the inertia bar. A new bolt restored the governor to its original sensitiveness.



Short Bolt Caused Trouble

E. A. Tichenor.

Beechwood, W. Va.

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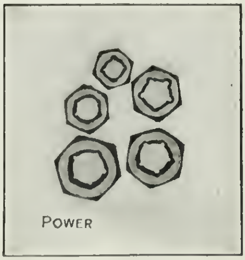
Dies Made of Steel Nuts

A set of dies made of steel nuts will be found almost invaluable in the plant. They are especially useful in clearing the threads on stud bolts, in place, when the studs are too close together to use an ordinary die stock. In the absence of some such means of improving the thread, the stud must be taken out and threaded in a vise, or, more likely, he nut will be forced on nd the stud broken before the joint is made up r insufficient pressure is ut on the gasket; then he joint will be lost. Vith the die nuts the studs an be left in place and ny obstruction cut away y running the die nut own on the thread and ff again.



Set of Dies

The danger of broken uds is greatly reduced when the threads are clear, as he tensile strength is easily sufficient to hold a joint, ut the torsional strength is so much lower that the ud may be easily twisted off. The labor involved in rilling out one broken stud will often equal that of making a complete set of die nuts as shown. They are made by taking steel nuts and inserting loosely fitting studs and drilling four or five small holes between the nut and stud. If the stud fails to unscrew freely, drill its center so as to release the threads. The cutting edges of the drilled holes should then be trued with a file and the nut hardened to suit the kind of work, and the job is complete.

John Powers.

New Bedford, Mass.

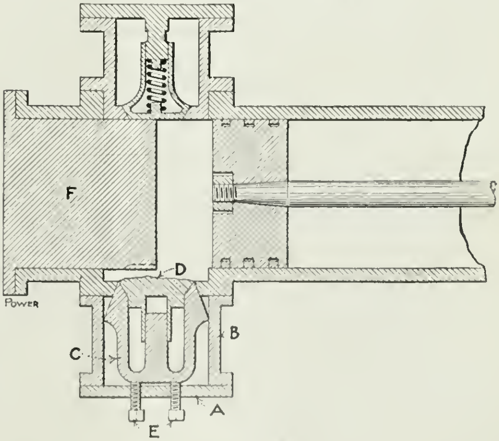
⁂

What Broke the Valve?

The suction valve blew out of a Ball ammonia compressor of the horizontal, double-acting type without warning or other signs of distress. The illustration shows the design of the suction and discharge valves. We found the bonnet *A* cracked in four pieces and the valve pot body *B* cracked the whole length on one side and part way in another place.

Numerous reasons were suggested to account for the accident. One was that a slug of liquid had caused the damage, but it was pointed out that it would be easier for the liquid to pass out through the discharge valve than to break the suction valve; besides, the machine was running rather warm at the time and this would not be the case if there was liquid enough present in the suction line to cause any trouble.

Another suggestion was that the setscrews *E* holding the cage *C* in place had backed out and allowed the cage to work up and down and hammer the bonnet until it cracked and blew out. This did not seem plausible either, because the cage is quite heavy, and the pressure has no tendency to shift it, and the valve *D*, if it was working free, would not lift it. However, the setscrews were gone over regularly on all the machines every week for some time, but none of them had worked loose.



Section of Valve

Three months later another valve blew out under identically the same circumstances on another machine. This time we noticed that the valve *D* had curled up on one edge, as if something had struck it a heavy blow. On closer examination, a mark on the piston near the bottom indicated where it had struck the valve. The valve, however, had no business being in a position where the piston could hit it when the piston was coming back if it was working properly, and even if it should stick open, the cylinder head *F* would prevent it from getting high enough for the piston to hit it.

It was found, however, that the cylinder head was worn away from the constant hammering of the suction valve every time it opened as indicated by the dotted lines. This tended to cock the valve over on one side when it struck the head and most likely caused the valve to stick; it also allowed the valve to raise high enough for the piston to hit it when it came back, thus causing the break.

To avoid further trouble, we turned the cylinder heads on each end of each machine half a turn, which gives a new surface for the valve to strike against and prevents it going up too far.

THOMAS G. THURSTON.

Chicago, Ill.

Home-Made Cable Clamp

Referring to the article by Walter R. Hodge, reprinted from the *Engineering & Mining Journal*, in the Aug. 4 issue of POWER, I would state that if anyone wants these clamps, it is not necessary to have a blacksmith make them; this style of clamp is furnished by oil-well and mill-supply dealers.

Such clamps are made for all sizes of cables from $\frac{3}{8}$ to $1\frac{1}{4}$ inch. The discount prices range from $1 to $4 per dozen. The clamps are usually furnished either in plain or galvanized iron.

L. M. JOHNSON.

Emsworth, Penn.

Examination Questions

Following are the questions asked recently by the board of examiners in Boston, of applicants for a second-class engineer's license, as sent in by one of our subscribers.

1. If at varying loads a McIntosh & Seymour engine runs slow or fast, how do you adjust the governor to make it run steadily?

2. How does the automatic work on a Pickering governor?

3. What braces are needed in the Heine boiler?

4. How do you test the Pickering governor to see that it is working?

5. If your fireman came up and told you the feed pipe was blocked with scale, how would you tell, without going inside of the boiler?

6. How do you feed from the heater to the boiler?

7. How do you distinguish the suction valve on a Deane duplex pump, also the discharge valve?

8. How do you pack the piston on this pump?

9. If you have two pumps exactly alike, one being used for feeding boilers and the other for pumping out-doors, how can you tell which is which, if all piping is concealed?

10. Can a single-acting pump be made to work double-acting?

11. If the end of the blowoff runs into a tank, how can you tell where a leak may be?

12. If you had a battery of six boilers, and the blowoff pipe broke on one of them, what would you do?

13. What and where is the follower plate on a pump?

14. Which is the direct and which the indirect side of a pump?

15. How do you find the clearance on an engine?

16. How does the valve gear operate on the Brown engine?

17. How does it operate on the Rollins engine?

18. How does it operate on the Putnam engine?

19. How high a lift has the poppet valve on the Putnam engine?

20. Suppose you lengthen the long reach rod, and shorten the short one, what effect does it have on the tandem compound engine?

21. What effect will the same adjustment have on a single-cylinder engine?

22. How would you ease up on the crankpin of the high-pressure side of a cross-compound engine when heating?

23. Suppose your fireman came up and said the piston on the direct side of the pump was broken; which side would you look at?

24. What difference would it make to the clearance by keying up on a solid end connecting-rod, and what difference would it make on one having gib and key?

25. At what point of the stroke does a slide valve cutoff?

26. How would you fix it to make it cut off at seven-eighth stroke?

27. How do you set a shaft governor?

28. If you had the valves on a riding cutoff one opening $\frac{3}{4}$ in. more than the other, how would you alter it?

29. If you bank your fires at night, and have plenty of water in the boiler—you come in the next morning and find the water out of sight; where did the water go?

30. If your engine is cutting off at one-fourth, then one-half, then two-thirds stroke, what is the trouble?

31. How much lap would you give a slide valve?

32. If one of the pistons is going slowly and the other going quickly on a duplex pump, what is the matter?

33. If you key up both crankpin and wristpin, would it make any difference to the clearance?

34. Is a compound engine more economical than a single-cylinder engine?

35. Is a single or duplex pump the most economical?

36. In case of accident, which is the quickest way to shut down a four-valve condensing engine not equipped with electric stop motion?

37. If the emergency stop and emergency throttle valve on a 1000-kw. Curtis steam turbine was out of commission, and the turbine dropped its exciter, what would you do?

38. What are the precautions to be observed when synchronizing or phasing a turbine set with a reciprocating set?

39. What do you understand by power factor?

40. What is a direct engine?

41. How would you place the eccentric back if it should slip?

42. What kind of valve is between the pump and pressure tank of a hydraulic elevator?

43. If there was too much air in the pressure tank, what effect would it have on the elevator?

44. If the governor belt broke on a Corliss engine, would the governor prevent the engine from racing or accelerating to the point of explosion?

45. How would you set a Corliss engine governor?

Engineers' Study Course

Elementary Mechanics--XXVI

Last Lesson's Answers

116. The time of flight, which is independent of the velocity of projection, may be found from equation (67), where $T_1 = \sqrt{\frac{2H}{g}}$. As the conveyor is 100 ft. above the ground the value of H is 100 ft., hence

$$T_1 = \sqrt{\frac{2 \times 100}{32.16}} = \sqrt{6.22} = 2.5 \textit{ sec.}$$

117. While the coal is falling it is also moving horizontally at the rate of 20 ft. per sec. From problem 116 the coal strikes the ground 2.5 sec. after leaving the conveyor; therefore, the point where the coal lands is at a horizontal distance of

$$2.5 \times 20 = 50 \textit{ ft. from the conveyor.}$$

118. At the instant it strikes the ground, the coal has two velocities—one of 20 ft. per sec. horizontally, represented by the line AB, Fig. 77, and a vertical one, due to gravity, represented by the line AD. The value of the velocity, due to gravity, is given by equation (41) where $V = gT_1$. In this case the time of flight is 2.5 sec., hence the velocity $AD = 32.16 \times 2.5 = 80.4$ ft. per sec. The resultant velocity is given by the diagonal AC of the parallelogram $ABCDA$.

$$\text{But } \overline{AC}^2 = \overline{AD}^2 + \overline{DC}^2 = 80^2 + 20^2 = 6800, \text{ or}$$

$$AC = \sqrt{6800} = 82.5 \textit{ ft. per sec.}$$

The resultant AC makes an angle BAC (see Fig. 77) with the horizontal. But $\sin BAC = \sin a = \frac{BC}{AC} = \frac{80}{82.5} = 0.97$. From a table of sines the angle a is found to be 76 deg.

119. The linear velocity of the ball is equal to $2 \times 3.1416 \times R \times N$, where R = the distance from the center of the spindle to the center of the ball, and N = the r.p.m., or

$$V = 2 \times 3.1416 \times \tfrac{15}{12} \times 100 = 785 \textit{ ft. per min.}, \text{ or } 13 \textit{ ft. per sec.}$$

If the ball were to break loose from the arm, it would move horizontally with a velocity of 13 ft. per sec., and at the same time gravity would pull it toward the ground. The time that would elapse before the ball strikes the ground is dependent upon the height of the ball from the ground, which is 15 ft. From equation (12), $H = \frac{1}{2} gT_1^2$, or $T_1 = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 15}{32.16}} = 1$ *sec.* (approx.) During this same time the ball would travel 13 ft., that is, the ball would strike the ground 13 ft. from the governor.

120. From problem 119, the time of flight is found to be one second.

Projectiles (continued)

Class III. Bodies projected at an angle to the horizontal.

In Fig. 78, assume an object to be projected from the point A with a velocity of V feet per second, at an inclination of a degrees with the horizontal, and let the line AB represent this velocity. Through the point A draw the horizontal and vertical reference lines AK and AN and on the diagonal AB construct the parallelogram $ANBMA$. The line AM will then represent the horizontal component of the velocity V, and will give the rate at which the projectile is moving horizontally. Likewise the line AN will represent the vertical component of the velocity V and gives the rate at which the projectile is moving vertically. The only force opposing the component V_1 is the resistance of the air, which, in this discussion, is assumed as zero, hence as long as the projectile is above the ground it will have a uniform horizontal displacement of V_1 feet per second.

The component V_2 is being reduced at a uniform rate by the action of gravity until finally it becomes zero, at which instant the projectile has reached its maximum elevation above the ground as represented by the point S, in Fig. 78. From this point on, the action of gravity is greater than the vertical velocity, with the result that the projectile is gradually drawn toward the earth and finally reaches it at the point K. The distance $ST = H$ gives the maximum height the body will rise and the distance $AK = R$ represents the range of the projectile.

At the end of the first second of flight the projectile would be at the point B, distant V feet from the point A, but during this second gravity acts and pulls the object toward the earth a distance of $\frac{1}{2} gT_1^2$ ft., or 16 ft., so that the true position of the projectile is at C, 16 ft. below B. Likewise at the end of the second second the projectile is at F, located $\frac{1}{2} gT_1^2$, or 64 ft. below D.

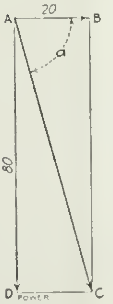


FIG. 77.

The path of the projectile may be plotted in a manner similar to that explained under Case II. Thus, through the point of projection A draw the line AK, and also the line AE at an angle of a degrees to AK, to represent the direction of projection. On this line locate the points A, B, D, E, etc., distant V, $2V$, $3V$, etc., from A. Through the points B, D, E, etc., draw the vertical lines BC, DF, EG, etc., and on these lay off to scale the distances through which a body would fall due to gravity in the given number of seconds. Thus at the end of the first second, the projectile would be at C, at the end of the second second at F, etc. A smooth curve drawn through these points will give the path or the trajectory of the body.

In Lesson XIX, it was shown that if a body be projected vertically upward with a given velocity that the total time of flight would be $T = \frac{2U}{g}$ seconds, where U is the vertical velocity of projection. In this case the vertical velocity is the vertical component of the velocity V, or $V \sin a$, hence when a body is projected at an angle of a degrees to the horizontal with a velocity of V feet per second, the total time of flight will equal $\frac{2 \times V\ sin\ a}{g}$, or,

$$T_1 = \frac{2\ V\ sin\ a}{g} \qquad (70)$$

The range, or horizontal displacement of the projectile, will equal the horizontal component V_1, or $V\ cos\ a$, times the whole time of flight, or,

$$R = V\ cos\ a \times T_1 \qquad (71)$$

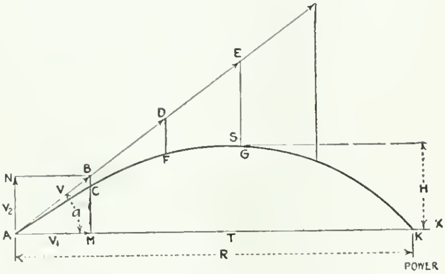


Fig. 78.

Now substituting the value of T_1 from equation (70), in equation (71), there results,

$$R = V\ cos\ a\ \frac{2\ V\ sin\ a}{g} = \frac{2\ V^2\ sin\ a\ cos\ a}{g}$$

but from the lessons in Trigonometry, $2\ sin\ a\ cos\ a = sin\ 2\ a$, therefore

$$R = \frac{V^2\ sin\ 2\ a}{g} \qquad (72)$$

When the angle $a = 45$ deg., the angle $2\ a = 90$ deg., and $sin\ 2\ a = sin\ 90\ deg. = 1$, and hence the horizontal range $R = \frac{V^2\ sin\ 90\ deg.}{g} = \frac{V^2}{g}$.

This demonstrates that a projectile will have its maximum range when the angle of projection is 45 deg.

The maximum height H that the projectile will rise above the horizontal is dependent upon the vertical component V_2 of the velocity V. Thus the value of H may be found from equation (43) by substituting for V the velocity $V_2 = V\ sin\ a$, thus,

$$H = \frac{V^2\ sin^2\ a}{2\ g} \qquad (73)$$

The velocity with which the projectile is moving vertically at any given instant during the flight may be found by considering that there are two velocities acting —one of $V\ sin\ a$ upward, due to the initial velocity of projection, and one of gT feet downward, due to gravity. Let U = the vertical velocity at the end of T seconds, then,

$$U = V\ sin\ a - gT \qquad (74)$$

where T = the time that has elapsed from the instant of projection.

If the value of U works out negative, it indicates that the projectile has reached its maximum elevation and has started downward.

There is a special case coming under Class III, namely, when a body is projected from a point at a given elevation from the horizontal, as, for example, the firing of a projectile from a cliff. The time of flight in such a problem may be determined as follows:

Let H = the elevation of the point of projection. Then the total net vertical displacement of the projectile will be $-H$ feet, as the projectile must rise to its highest point and then fall H feet below the point of projection. The vertical velocity is $V\ sin\ a$. From equation (38), $S = UT - \frac{1}{2}\ gT^2$, and as $S = -H$, and $U = V\ sin\ a$, it follows that,

$$-H = V\ sin\ a \times T - \frac{1}{2}\ gT^2 \qquad (75)$$

where T is the total time of flight.

Study Questions

121. A 12-in. gun discharges a projectile with a velocity of 1200 ft. per sec. If the gun is inclined to the horizontal at an angle of 45 deg., find the time of flight.

122. At what distance from the gun will the projectile strike the ground?

123. Find the maximum distance that the projectile rises above the ground.

124. If the gun is on a cliff 500 ft. above the sea, where would the projectile strike the water if fired under the conditions stated in problem 121?

125. What is the total time of flight?

* * *

Boston's Smoke Report

The annual report of the Board of Gas and Electric Light Commissioners for Massachusetts which enforces the smoke law for Boston and vicinity, shows that for 1913 this work was carried on with good results.

As many know, the smoke law for Boston classifies stacks, stationary, marine and locomotive; the locomotive class covers all locomotives without regard to size while stationary and marine stacks are subdivided on a top-area basis, each size stack being allowed to emit objectionably dense smoke for time limits based on the smoke density, anything above and including No. 2 Ringelmann chart being considered dense.

During the year observations were made of 35,424 stacks, 27,423 being stationary, 7393 locomotive and 608 marine. Of these, 930 stationary, 252 locomotive and 43 marine stacks emitted smoke in excess of the amount allowed by the law. The number of stationary stacks emitting smoke in excess of the amount allowed, due to carelessness of operation was 773 against 944 for 1912. Observations were made on stacks of 115 public-service plants, 485 manufacturing plants, 297 office-building plants and two for residences. Of these, those emitting smoke in excess of that allowed were public service, 64; manufacturing, 225; and office buildings, 76.

The law went into effect July 1, 1900, and the comparative figures for the three years show gratifying progress.

* * *

Ellison Cement—After several years of experimentation on a cement for glass tubes in metal casings which would not be affected by mineral oils and would yield under expansion in setting, thus relieving the glass and cement cup of undue strains, an excellent cement has been developed by Lewis M. Ellison, as follows: Two parts litharge and three parts granulated cork, fineness of about granulated sugar, mixed with glycerin to usual consistency; coated, when set, on the surfaces exposed to atmospheric action with valspar or similar varnish. The cork compensates for the expansion, litharge-glycerin cement being too hard and having too great expansion. For level glasses, plaster of paris mixed with water being too hard for thin wall glass and also having too great expansion in setting, two parts plaster is mixed in water with one part cork.

Proposed Changes in Massachusetts Boiler Rules

In compliance with Sect. 26, Chapt. 465 of the Acts of 1907, Commonwealth of Massachusetts (as amended by Sect. 2 of Chapt. 393 of the Acts of 1909), a public meeting will be held by the Board of Boiler Rules[*] to consider the following changes in the present Massachusetts steam boiler rules.

PART II

SECTION 1

Paragraph 1—The pressure allowed on a boiler constructed wholly of cast iron, and boilers known as cast iron sectional boilers, shall not exceed fifteen (15) lb. per sq.in.

Paragraph 2—The pressure allowed on a boiler the tubes of which are secured to cast iron headers, also on cast iron mud drums and malleable iron headers or mud drums, shall not exceed fifteen (15) lb. per sq.in.

Paragraph 6—(Additional.) The shearing strength of the rivets and the crushing strength of the plate in front of the rivets shall be ample to take care of the pressure on the head.

Paragraph 7—The lowest factors of safety used for boilers, the longitudinal joints of which are of lap-riveted construction, shall be as follows:

(e) Boilers over twenty-five (25) years old, of lap-seam construction, shall not carry a pressure in excess of fifteen (15) lb. per sq.in.

SECTION 2

Paragraph 9—Interpolate, after the word degrees in fourth line, the words, or about ninety (90) degrees.

Paragraph 10—Fusible plugs, as required by Sect. 20, Chapt. 465, Acts of 1907, shall conform to the following specifications:

SPECIFICATIONS FOR MASSACHUSETTS STANDARD FUSIBLE PLUGS

All fusible plugs shall consist of a bronze casing, holes in which shall be reamed and tinned before being filled, and shall be filled with Banca tin.

All fusible plugs shall be stamped by the manufacturers with their names across the face of the plugs with letters not less than one-eighth of an inch (⅛") in height, and the letters MASS. STD.

The outside diameter of the plug is to be of the standard pipe threads.

No fusible plug shall be used for a longer period than one (1) year.

Paragraph 12—Add to subparagraphs (l), (m), (q), (r) and (t) the words, and extending not less than one inch (1") inside of boiler.

Paragraph 13—Interpolate the word "brass" before the word syphon on second line.

Paragraph 17—Each boiler shall have two (2) or more gage cocks, the centers of which shall be located vertically within the range of the visible length of water glass, when the maximum pressure allowed does not exceed fifteen (15) lb. per sq.in., except when such boiler has two (2) water glasses located not less than three (3) feet apart on the same horizontal line.

Paragraph 18—Each boiler shall have three (3) or more gage cocks, the centers of which shall be located vertically within the range of the visible length of water glass when the maximum pressure allowed exceeds fifteen (15) lb. per sq. in., except when such boiler has two (2) water glasses, located not less than three (3) feet apart, on the same horizontal line.

Paragraph 25—When there are two (2) connected boilers (gravity return system), one check valve and a stop valve shall be installed in the branch pipe to each boiler. (Omit Fig. 1, as shown.)

SECTION 3

Paragraph 2—A boiler having two (2) sq.ft. of grate surface shall be rated at three (3) hp. when the safety valve is set to blow at fifteen (15) lb. per sq.in. or less.

SECTION 6

Paragraph 1—When a boiler is tested by hydrostatic pressure the pressure applied shall not be less than one and one-quarter (1¼), nor more than one and one-half (1½) times the maximum allowable working pressure; except that twice the maximum allowable working pressure may be applied on boilers permitted to carry not over fifteen (15) lb. pressure per sq.in.

Paragraph 2—When making annual inspections on boilers constructed wholly of cast iron, or boilers known as cast iron sectional boilers, a hydrostatic pressure test of not less than fifteen (15) lb. and not more than twice the maximum allowable working pressure, shall be applied.

PART III

Page 21—(Heading.) These rules, in addition to the rules contained in Part II, apply to boilers installed after May 1, 1908, and to any repairs or changes made hereafter.

SECTION 1

Paragraph 3—There shall be two (2) classes of open hearth boiler plate and rivet steel; namely, firebox steel and extra soft steel, which shall conform to the following limits in chemical composition:

	Firebox Steel (Per cent.)	Extra Soft Steel (Per cent.)
Phosphorus shall not exceed........	Acid 0.04 Basic 0.03	Acid 0.04 Basic 0.04
Sulphur shall not exceed...........	0.04	0.04
Manganese	0.30 to 0.50	0.30 to 0.50

Paragraph 5—The two (2) classes of open hearth boiler plate and rivet steel—namely, firebox steel and extra soft steel—shall conform to the following physical qualities:

	Firebox Steel	Extra Soft Steel
Tensile strength, pounds per square inch	52,000 to 63,000	45,000 to 55,000
Yield point, in pounds per square inch, shall not be less than	½ T. S.	½ T. S.
Elongation per cent. in eight inches shall not be less than	26	28

Paragraph 7—The two (2) classes, etc.

Paragraph 7 (d)—Omit the words "flange or boiler steel."

SECTION 2

Paragraph 1—Shells, drums, butt straps, heads, combustion chambers, furnaces, or any plates that require staying or flanging, shall be of open hearth firebox or extra soft steel, as specified in paragraphs Nos. 3 and 5, Sect. 1, Part III of these rules.

Omit paragraph 2.

SECTION 3

Paragraph 6—Cross pipes connecting the steam and water drums of watertube boilers, and cross boxes, shall be of wrought or cast steel when the working pressure exceeds fifteen (15) lb. per sq.in.

Paragraph 7—Mud drums of watertube boilers shall be of wrought or cast steel when the working pressure exceeds fifteen (15) lb. per sq.in.

Paragraph 8—Pressure parts of superheaters, attached to the boilers or separately fired, shall be of wrought or cast steel. Cast iron for superheat is prohibited.

Paragraph 10—Waterleg and door frame rings, of vertical firetube and locomotive type boilers shall be of wrought or cast steel, or wrought iron.

After present paragraph 11. DOMES or DRUMS.

Domes or drums shall only be allowed on a locomotive type boiler, and shall be located on the barrel of the boiler, but not on the wagon top.

Domes or drums shall be made of the same thickness and quality of material as the boiler shell.

When the pressure desired does not exceed one hundred (100) lb. per sq.in. the longitudinal joints of such domes or drums shall be of double riveted lap construction, and the flange shall be double riveted to the boiler shell.

Heads of domes or drums shall be convex.

When a hole larger than four inches (4") in diameter is required in a boiler which is constructed with a dome it shall be reinforced to compensate for the metal removed.

At least two (2) drain holes three-quarters of an inch (¾") in diameter shall be located in the shell under a dome, at the lowest point where water can collect, for the purpose of draining.

Paragraph 2—A manufacturer who desires to construct Massachusetts Standard boilers shall send a written application to the Board of Boiler Rules, and receive written authority from said Board before taking any steps toward the construction of a Massachusetts Standard boiler. A detailed list of shop equipment must accompany the manufacturer's application for such authority; also advice of the name of the State inspector or of the authorized inspector holding a certificate of competency as an inspector of steam boilers for this Commonwealth and in the employ of an insurance company authorized to inspect and insure steam boilers for this Commonwealth, who will examine during construction and stamp Mass. Std. upon completion a boiler constructed in strict accordance with these rules. Upon receipt of said application the Board will designate the style of stamping which it will approve, after the following model:

---

[*] Address, State House, Boston, Mass.

MASS. STD.
1
(Designation by Board.)

The manufacturer shall then submit a five-inch by three-inch (5-in.x3-in.) brass or copper plate, showing exactly the style of stamping designated by the Board, for approval; the height of letters and figures to be not less than one-fourth of an inch (¼-in.).

Paragraph 2—Renumber this paragraph, last six lines to read:

Each boiler shall be stamped by the builder, in the presence of the inspector, with a serial number and with the style of stamping shown in the facsimile previously approved by this Board.

Before present paragraph 3:

Any inspector holding a certificate of competency as an inspector of steam boilers for this Commonwealth may make final inspection and test on a boiler built under the rules of the Board of Boiler Rules of the Commonwealth of Massachusetts, provided the manufacturer of said boiler, or his representative, makes affidavit under oath that said boiler has been so constructed, and furnishes the record of a properly authorized inspector who has followed the construction of the boiler.

Before Paragraph 10—The efficiency of the longitudinal joint of a shell or drum when welded by the forging process shall not exceed the following:

55.0 per cent. when the shell plates are stamped 52,000 T. S.

54.0 per cent when the shell plates are stamped 53,000 T. S.

53.0 per cent. when the shell plates are stamped 54,000 T. S.

52.0 per cent. when the shell plates are stamped 55,000 T. S.

51.1 per cent. when the shell plates are stamped 56,000 T. S

(Note—56,000 lb. will be the highest tensile strength used in calculating the maximum allowable working pressure on a shell or drum the longitudinal joints of which are welded by the forging process, this being irrespective of a higher tensile strength than 56,000, which may be stamped on the plates. The formula for calculating the working pressure is given in Paragraph 1, Sec. 4, Part III of these rules.)

SECTION 4

Paragraph 16—The minimum thickness of a convex head shall be determined by the following formula, excepting that said thickness shall not be less than one-fourth of an inch (¼ in.):

$$\frac{8.33\,R \times P}{T.S} = t$$

The minimum thickness of a concave head shall be determined by the following formula, excepting that said thickness shall not be less than one-fourth of an inch (¼ in.):

$$\frac{8.33\,R \times P}{0.6\,(T.S.)} = t$$

Paragraph 16—(Addition to paragraph). The radius to which the head is bumped shall be at least equal to the diameter of the shell to which the head is attached.

The radius to which the curve shall be made close to the flange on a concave or convex head, shall be not less than four (4) times the thickness of the material in the head.

Paragraph 18—When a convex or concave head has a manhole opening, the flange shall be turned inward, and to a depth of not less than three (3) times the thickness of the head, measured from the outside of the boiler.

Paragraph 25—(Add to paragraph). The vertical pitch of staybolts, measured from the rivets in the lower tube sheet to the first row of staybolts, shall not be greater than the prevailing pitch of staybolts.

Paragraph 31—When a flat-head has a manhole opening, the flange of which is formed from the solid sheet and turned inward to a depth of not less than three (3) times the thickness of the head, measured from the outside of the boiler, an area two (2) inches wide all around the manhole opening, as shown in Fig. 16, may be deducted from the total area of head, including manhole opening, to be stayed.

Present figure 17 to be renumbered 16, and similar change made in numbers of all figures, on account of omitting figure number 1.

Paragraph 33—(Add to paragraph). Stayrods longer than three (3) ft., such as are used for bracing the segment of a circle, shall have not less than 0.7854 sq.in. sectional area.

Before Paragraph 40—All staybolts shall be drilled, both from the outside and inside ends, to a depth of not less than one-half inch (½ in.) inside the boiler plate, and their diameter shall be three-sixteenths of an inch ($\frac{3}{16}$ in.).

Before Paragraph 40—All nozzles on boilers shall be of pressed or cast steel, when the pressure desired is greater than fifteen (15) lb. per sq.in.

Paragraph 40—Omit the example and the formula at end of paragraph.

Before Paragraph 41—All boilers and parts of boilers shall be three-sixteenths of an inch ($\frac{3}{16}$ in.) thick.

Paragraph 41—The thickness of cast iron blank flanges shall not be less than that specified by the manufacturers' standard for high pressure.

Paragraph 46—The calking edges of plates and heads shall be beveled. Calking shall be done with a round-nosed tool.

Before Paragraph 47—The edges of plates and butt straps, inside and outside of boiler, shall be planed to a depth of not less than one-eighth of an inch (⅛ in.) to remove the crystallized metal caused by the action of the shear.

Before Paragraph 51—SPECIFICATIONS FOR TUBES.

Tubes for water-tube boilers, pipe boilers or superheaters shall be made without welds, and shall be seamless drawn.

Tubes for fire-tube boilers may be welded of steel or charcoal iron.

The physical tests of all tubes shall be as follows:

Tubes shall be free from all surface defects. The defects to be particularly avoided in seamless tubes are tears, snakes, checks, slivers, scratches, laps, pits, rings and sinks.

All seamless-steel cold-drawn tubes shall be annealed as a final process. One or more tubes shall be selected at random from each charge of the annealing furnace, and coupons cut from them for testing.

TEST ONE—A piece three inches (3 in.) long, cut from the first tube, shall be flattened by hammering until the sides are brought parallel with the curve on the inside at the ends not greater than three (3) times the thickness of the metal, without showing cracks or flaws.

TEST TWO—A flange shall be turned all around the end of the tube to a width equal to three-eighths of an inch (⅜ in.) beyond the outside body of the tube.

Tests one and two shall be done cold.

When hot finished tubes are furnished, the tubes shall pass the same manipulating test as cold-drawn tubes, but do not have to be annealed. Each tube shall be subjected to an internal hydrostatic pressure of one thousand (1000) lb., without showing signs of weakness or defects.

All tubes shall stand expanding, flanging over on the tube plate, and beading, without flaw or crack.

All lap-welded tubes shall be made of charcoal iron or mild steel, and shall conform to the following tests:

Tubes shall be free from defective welds, cracks, blisters, scale, pits and sand marks.

The following tests shall be made before shipment by the manufacturer:

TEST ONE—A test piece three inches (3 in.) in length, cut from a tube, shall be flattened by hammering until the sides are about parallel with the curve on the inside at the end, not more than three (3) times the thickness of the metal without showing cracks or flaws, with bend at one side being in the weld.

TEST TWO—A second tube shall have a flange turned over at right angles to the body of the tube, and shall have a width equal to three-eighths of an inch (⅜ in.) beyond the outside body of the tube.

All work done shall be done cold.

Each tube shall be subjected to internal hydrostatic pressure of five hundred (500) lb. per sq.in., without showing signs of weakness or defects.

All steel tubes shall have ends properly annealed by the manufacturer, before shipment, and shall stand expanding, flanging over on the tube plate, and beading, without flaw, crack or opening in the weld.

The manufacturer of boiler tubes shall furnish to the purchaser of each lot of tubes a statement of the kind of material of which the tubes are made, and that the tubes have been tested and have met all the requirements of the rules. The statement shall be furnished to the boiler manufacturer using the tubes, who shall show them to the boiler inspector when shop inspection of the boiler is made.

(After the foregoing specification for tubes)—The first two rows of tubes exposed to products of combustion, in water-tube boilers, shall be two (2) gages heavier than the prevailing thickness of tubes in said boilers.

(Second paragraph after specification for tubes)—No lap-welded tube shall be used in water-tube boilers. No old boiler shall be retubed with lap-welded tubes.

Paragraph 52—When it is necessary to place a fusible plug in a tube, an extra thick tube shall be provided for that purpose, which shall not be less than three-eighths in.

Paragraph 53—(After the tabulation). If the thickness of the material in the boiler is not sufficient to give such number of threads, there shall be a standard commercial pressed-steel flange, cast-steel flange or steel plate, substantially riveted to the boiler, so as to give the required number of threads. A feed-pipe connection shall be fitted with a brass or steel boiler bushing.

(Before paragraph 54)—SPECIFICATIONS FOR CAST STEEL.

Chemical properties:

Phosphorus, not over 0.05 per cent.

Sulphur, not over 0.05 per cent.

Physical properties.

Tensile strength, lb. per sq.in., 50,000 to 60,000.

Elongation in 2 in. 23 per cent.

Reduction of area, 30 per cent.

All steel castings must receive such heat treatment as will produce fine grain, homogeneous and tough metal, free from slag, cracks and cavities, injurious blowholes or other defects.

Cast-steel, cast-iron or malleable-iron boiler fittings shall not be used unless made by regular processes and by manufacturers who stamp such fittings with their trade mark or identifying stamp, and who guarantee the castings to possess the chemical and physical properties stated in these rules.

Before Paragraph 58—There shall be not less than eleven-sixteenths of an inch ($\frac{11}{16}$ in.) bearing surface for a manhole gasket.

Paragraph 64—A vertical fire-tube boiler which does not have a manhole, except the boiler of a steam fire engine, shall have not less than seven (7) handholes, located as follows:

Two (2) in the shell at or about the line of the crown sheet, and diametrically opposite each other.

One (1) in the shell at or about the line of the fusible plug, except a vertical fire-tube boiler having a manhole in the shell or head, through which the fusible plug is accessible.

Two (2) in the shell at the lower part of the waterleg, and diametrically opposite each other.

Two (2) located at or about the waterline of the boiler, and diametrically opposite each other, except a vertical fire-tube boiler having a manhole.

Paragraph 88—Omit the words, or cast iron, in fourth line.

Paragraph 69—Omit the words, or cast iron, in third line.

Paragraph 70—(Addition to paragraph)—No cast iron shall be used in lugs or brackets in any steam boiler.

Before Paragraph 71—REINFORCING PLATES WHERE BRACKETS ARE ATTACHED.

In all cases where brackets or other fixtures subjected to any working strain are attached to a portable boiler, the plates to which these brackets are attached shall be reinforced with plates of the same thickness as the outer plates of the boiler, and securely riveted together. The outer rows of rivets attaching reinforcing plates to boiler must be at east three inches (3 in.) outside of the bracket. All brack-ets shall be properly fitted to the plates, flat or curved, with tud holes drilled to suit the holes in the brackets, which nust be drilled to templets; and the studs attaching same hall be tapped through both plates where reinforced. No ap bolts will be allowed.

SECTION 5

Paragraph 4—Omit the words, and thirty-five, and change gure to 100.

Paragraph 5—Omit the words, and thirty-five, and change gure to 100.

Paragraph 7—Omit paragraph.

Paragraph 8—The feed pipe of a boiler shall have open nd or ends. When one or more globe valves are used on feed pipe, the inlet shall be under the disk of the valve.

Paragraph 9—The feed water shall discharge about three-fths (⅗) the length of a horizontal return tubular boiler om the front head, and at or about the central rows of ubes above the tubes, when the diameter of the boiler ex-eeds thirty-six inches (36 in.) and the pressure allowed ex-eeds fifteen (15) lb. per sq.in. The feed pipe shall be car-ed through the head with a brass or steel boiler bushing ad securely fastened inside the shell above the tubes.

Before Paragraph 10—When a horizontal return tubular boiler, the diameter of which does not exceed thirty-six (36 in.), has no manhole opening, and the pressure desired is greater than fifteen (15) lb. per sq.in., the feed pipe shall enter the front tube sheet above the tubes, and below the waterline of the boiler, through a bushing, and an internal feed pipe, not less than three (3) ft. in length, screwed into said bushing, the end of said pipe being open.

Paragraph 13—In fourth line, change pressure to fifteen (15) lb. per sq.in.

Paragraph 17—In first line, change pressure to fifteen (15) lb.

Paragraph 18—In second line, omit the words, and thirty-five, and change figure to 100.

Paragraph 23—In second line, change pressure to fifteen (15) lb.

Before Paragraph 24—BLOWOFF ON WATER COLUMN. On each water connection to a water column where there is a right-angle turn, there shall be located at least one (1) gate valve and pnpe of a diameter not less than one-half inch (½ in.), for the purpose of blowing out said water pipe, except a right-angle turn inside of smoke box.

Paragraph 31—Make this paragraph, paragraph 4, sec. 6, part 2, p. 13.

After present paragraph 31—When a dry pipe is used in the steam space of a boiler, it shall be made of the standard thickness of pipe, and be properly secured; shall have both ends closed, and shall be slotted on the top side of the pipe. The area of the slots shall be equal to not less than four times the area of the steam outlet.

SECTION 6

Omit paragraphs 1 ad 2.

Paragraph 3—Omit the words, passed by joint, and change the word inspection to the word inspected.

Omit present paragraph (a) and change other paragraphs as follows:

(a) Six (6) for boilers, the longitudinal joints of which are of lap-riveted construction, diameters up to and including thirty-six inches (36 in.).

(b) Eight (8) for boilers, the longitudinal joints of which are of lap-riveted construction, diameters over thirty-six inches (36 in.).

(c) Four and five-tenths (4.5) for boilers, the longitudinal joints of which are of butt and double-strap construction, age not exceeding ten (10) years.

(d) Five (5) for boilers, the longitudinal joints of which are of butt and double-strap construction, age over ten (10) years.

The hydrostatic pressure test on such boilers shall be one and one-half (1½) times the maximum allowable pressure obtained by using the above factors of safety.

Page 52—(Before repealing clause.)

A boiler on which a lap crack is discovered shall be immediately discontinued from service.

The ogee form of construction at the lower end of furnace sheet is hereby prohibited.

*

An English Boiler Explosion

On the morning of Aug. 17 a large Rastrick boiler, heated by waste gases, exploded in the puddling shed of the Thornkill Iron and Steel Works, Dewsbury, Yorkshire, England, converting iron buildings and a group of puddling furnaces into a tangled mass of debris. Of 35 men employed in the puddling shed seven were killed and nearly all were injured.

The evidence given at the inquest revealed a tragically simple solution of the disaster, as reported in "The Mechanical Engineer" of Aug. 21. Shortly after six o'clock, on the morning of the explosion, the chief engineer of the works noticed that steam was issuing rather freely from the lever safety valve, and presuming that it was due to leakage, instructed the engine-driver to hang a little more weight on the lever and this he proceeded to do by slinging an iron bar on it by means of S hooks in the belief that since the boiler was coupled to others, any excess of pressure would be relieved by their safety valves. It appeared that when the escape of steam was first noticed the pressure was then above the working point, and that the stop valve was closed so there was no outlet for the accumulating pressure until it burst the boiler. Had the boiler been fitted with duplicate safety valves, it is very improbable that both would have been defective at the same time and the escape of steam from both of them would have been more likely to excite suspicion and have prevented overloading of the boiler.

The Rastrick boiler has many objectionable features and among the older generation of English engineers has an unenviable reputation, owing to its association with some of the most disastrous boiler explosions on record.

The shell of this type of boiler is, roughly speaking, a plain vertical cylinder with hemispherical ends. It has been constructed with diameters ranging from about 6 ft. to as much as 9 ft., and heights from about 16 ft. to 25 ft. A vertical central flue tube extends from the bottom to about half the height of the shell, and is connected to it by two or four horizontal branches, according as the boiler is fired by waste heat from one or two pairs of puddling or heating furnaces. An annular brickwork flue is formed around the shell, divided by partition walls into as many compartments as there are furnaces. The waste heat from each furnace enters one of these compartments at the base of the boiler and thence through a damper to one of the horizontal branch tubes connecting to the central flue tube, through which the gases pass to the main flue leading underground to the chimney. The arrangement of the boiler and iron furnaces is compact since the boiler itself occupies little floor space, and the puddling or heating furnaces can be conveniently grouped around its base, which features have undoubtedly contributed to its extensive use in the past. But the virtues of the Rastrick boiler as a steam generator are so few and its vices so many that it has been largely discarded by the majority of English engineers in favor of special adaptations of the Lancashire, Cornish or water-tube type, though a few are still in existence."

* *

Annual Convention of American Boiler Manufacturers' Association

The 26th annual convention of the American Boiler Manufacturers' Association was held at the Waldorf-Astoria, New York City, on Sept. 1, 2 and 3, and transacted considerable business of value not only to the association, but to boiler manufacturers generally, although the attendance of active workers present was less than had been expected.

A feature of the meeting was the opportunity afforded to still further advertise the coming hearing to be held in New York City on the 15th inst., pursuant to the call sent out by the A. S. M. E, to discuss their proposed new uniform specifications for boiler design, construction and materials.

The sessions were presided over by Vice-President Thomas M. Rees, of Pittsburgh, in the absence of President Meier, and the convention was opened by an address of welcome by Henry Bruere, city chamberlain, who referred to the changed attitude of municipal government toward the community with respect to efficient service for the public welfare. He said New York City had achieved a rather unenviable reputation in former years on account of its police graft scandals, etc., but that it had fully retrieved and has since furnished an example to the entire country of what can be accomplished for a city through the active participation of its best citizens.

W. H. S. Bateman, of Philadelphia, responded to the address of welcome, and took occasion to defend Philadelphia's reputation against the impeachment that the Quaker City is a little slow.

A recent circular letter of the Steamboat Inspection Service, referring to fusible plugs, was discussed by Messrs. Schaaf, Rees and others, Mr. Rees contending that those who were interested in Western river practice believe that there is no necessity of having more than one plug in the flue and one in the shell, and that the plugs should not be placed where they might necessitate the engineer lowering the water in order to get at them, as through such lowering of water there might be occasioned serious interference with the safe navigation of the boat. He did not believe there had ever been a case where a fusible plug properly made and properly placed had failed to give timely warning that the water in the boiler had fallen below the proper level. He thought the provision that the plugs must be renewed after four months' service was an unnecessary hardship, and in one case had occasioned an extra expenditure of about $1500.

H. J. HARTLEY stated that the Lloyds' requirements do not specify any plug at all, but on the first indication of a leak or blowout, a plug is merely screwed in and the matter remedied in that way.

A. J. SCHAAF stated that in the case of locomotive boilers, the requirements in the circular would make necessary the placing of three plugs in the crown sheet; one 12 in. from each end and one in the center. In a two-flue boiler, before this provision went into effect, one plug was placed 4 ft. from the forward end in the shell just under the fire line and one in the after end in the flue. He believed it a mistake to have an extra plug in a two-flue marine boiler in the middle of the flue on account of its being the coldest part of the boiler. If safety is the object, it ought to be in the shell 8 or 10 ft. from the forward end, where it would get the heat of the furnace.

The proceedings of the second day were opened by Secretary Farasey reading a communication from Colonel Meier, in which the latter made a strong plea for uniform boiler laws and specifications. He referred to the beneficial working of the steamboat and locomotive inspection laws under federal control, but said it would require a constitutional amendment to put stationary boilers under similar supervision. However, this difficulty could be overcome by having the different states accept the uniform specifications drawn up by the A. S. M. E. and concurred in by the various boiler interests.

Colonel Meier sent hearty greetings to the members present, with the assurance that only illness prevented his attendance. He also stated that it would be impossible for him to accept the presidency for another year. At the close of his sixth year's administration, he had never held an office in which he had been so generously and warmly supported as in that of presiding officer of the A. B. M. A.

Appropriate action on Colonel Meier's retirement was taken later.

JOHN A STEVENS, from the committee of the A. S. M. E., addressed the convention, explaining the methods adopted by the A. S. M .E. in formulating its proposed standard specifications for the construction of steam boilers and other pressure vessels and for their care in service. He felt that regard for safety of life and property should far outweigh any consideration of cost, and the object of the new specifications was to insure the best possible design, construction and materials. He invited suggestions from all quarters, and stated that the opinions and criticisms of some sixteen hundred engineers who were recognized authorities on boiler design and construction had been requested by letter and the replies collated and considered; that the hearing on Sept. 15 was for the purpose of still further bringing out and discussing suggestions looking to the formulation of the very best specifications possible. He understood that the Wisconsin law recently enacted was being held up before being put into effect, awaiting the result of this conference, but was of the opinion that this law was a retrograde step from the proposed standard in that it called for reducing the factor of safety from 5 to 4½, and allowed the use of flange steel in place of firebox in boiler shells.

GEORGE A. LUCK, chairman of the Massachusetts Board of Boiler Rules, next read a schedule of certain proposed changes which the board is considering putting into effect, but which it is at present holding up for hearing until after the proposed A. M. S. E. conference on Sept. 15.

In reply to a question by C. S. Barnum, Mr. Luck stated that the board, with reference to welded joints, called for the forging process, not considering acetylene or electric welding advisable.

In reply to a question by John L. Gill, Mr. Luck stated that lugs or brackets were permitted to be attached to portable boilers with reinforcing pad, the wording of the rule being "may be." He explained that in Canada it is customary to put on lugs on portable boilers with reinforcing pads, and that the board had been requested to make the proposed change in order that boilers so built will be accepted in Canada as being in accordance with the practice there.

MR. GILL inquired, if a line of rivets went through the shell in a longitudinal position, whether this would not make a single-riveted boiler out of it so far as an allowance for pressure was concerned. Mr. Luck replied that it was not necessary to put the rivets so close together as to bring the boiler within less limits of pressure; that one does not have to reduce the efficiency in the joint, and besides, the reinforcing pad can be placed on the inside of the boiler.

L. E. CONNELLY, chairman of the Committee on Uniform Boiler Laws, then presented the report of his committee, which called attention to the lack of any boiler legislation during the past year, and reviewed briefly the coöperative work of the various societies toward uniform laws and specifications.

W. C. CONNELLY called attention to a recent communication received by him from several of the steel makers, in which he had been notified that on and after Oct. 1, they would refuse to accept orders for firebox steel with a range of more than 8000 lb. tensile strength.

A. B. CARHART urged the advantages of using two small pop safety valves on each boiler rather than one large valve, and emphasized the waste of coal and steam and the lack of economy through the frequent blowing of safety valves too large or unsuitable and the longer life of boilers secured by the use of accurate steam gages and well designed valves.

CHARLES F. KOOPMAN, referring to the matter previously mentioned by Mr. Connelly of leeway in tensile strength, thought that this would come up sooner or later in the Massachusetts law. He had just learned that under the Massachusetts law, another 1000 lb. was to be given, from 52,000 to 63,000, instead of from 52,000 to 62,000. The mills were asking for a leeway of 8000 lb., bringing the tensile strength down to 54,000 lb. In figuring on a 72-in. boiler, ½ in. thick, 150 lb. working pressure, this would mean a change in the construction of boilers in Massachusetts. This had been brought up in Boston, and the speaker had suggested to the mill that they refrain from making an arbitrary rule of that sort without first learning what effect it would have upon the boiler-manufacturing industry.

T. M. REES said he had always been a believer in high tensile strength, and he did not want to be confined to a low tensile strength, which would limit the thickness of the material. He always succeeded in getting the steel that he wanted by paying enough for it, and had just received word that after six years' constant service night and day with 185 to 190 lb. pressure, only one little fire crack had shown up on a certain piece of work.

MR. BLAKE said there had been some dispute as to the exact date when the first steel was worked in boilers, to which Mr. Rees replied that the first steel ever put in a steamer was in the mud drums of the steamer "Tom Rees" in 1869, which the local inspector at that time said must be taken out because made of steel and not iron. The builders refused to take them out because there was nothing in the law saying that the steel could not be used, and it remained there for years. The steel was made by Hussey, Wells & Co. by the crucible process in 1868.

As a representative of one of the large steel companies, **J. O. Leech** said:

"There seems to be considerable misapprehension about the position taken by the steel manufacturers in regard to tensile strength. All that the steel manufacturers are asking for is a reasonable working range. Less than 8000 lb. range is considerable of a hardship. We do not care where that range lies, we can make the steel any range within reason. We believe that you can obtain the very best quality of steel for boiler purposes with a tensile strength up to 68,000, or perhaps higher. Marine boilers are regularly built with a minimum of 60,000 lb. All we are asking is a reasonable working range, and we do not believe it is necessary to specify a maximum of 62,000 or 63,000 lb. to obtain the best quality of steele.

"Slight differences in chemical composition or in physical properties do not alone govern quality as now designated by the terms flange and firebox. A comparison of existing specifications will show that some have as high sulphur limits for firebox quality as others allow for flange quality. Some specifications for firebox steel have the same ranges in tensile strength that others do for flange quality, which is an indication that these properties alone do not govern quality."

Replying to a question of G. S. Barnum as to what governs the quality, Mr. Leech said that careful manufacture and inspection were chiefly responsible. He further added that phosphorus and sulphur within reason have nothing to do with the tensile strength, which is governed principally by the carbon and manganese. A piece of 68,000-lb. steel cannot be expected to show as much elongation or as much reduction of area as a piece of 60,000-lb. tensile strength, because as the tensile strength goes up, the ductility drops; but the same relative ductility will be had with 68,000 lb. tensile strength as with the 60,000 lb.

WILLIAM H. BOEHM: I do not know whether the advantage of having a narrow range is well understood. Of course, that is the whole point of the discussion, as to what is the advantage of asking the steel manufacturers to work to a narrow range, that is, a range of 8000 lb. or less. I have been led to believe that you cannot secure high tensile strength and great ductility from the same material. If you specify high tensile strength, you necessarily must have the material that is more or less brittle—a material that can be easily fractured. In boilers, a material is wanted that will stretch and not fracture; so if we specify a material of 50,000 lb., we are specifying one that we think is ductile, and we do not want it to come to us at 60,000 lb. tensile strength, because then we are going to get a material that is less ductile and is more easily fractured. That is the real reason why we want the manufacturers to work to a narrow range if they can do it.

EARNEST T. CHILD stated that the proposed new A. S. M. E. specifications would limit cast-iron boilers to 15-lb. pressure, and as representing the National Association of Steam and Hot Water Fitters, in their behalf he asked the assistance of the A. B. M. A. to obtain a modification of that recommendation with particular reference to cast-iron sectional boilers for hot-water heating. The installation of cast-iron sectional boilers for heating water is prohibited in office buildings over 35 ft. high.

WILLIAM H. BOEHM, as a member of the A. S. M. E. committee, inquired of Mr. Child whether the reason he made this request to increase the allowable working pressure on such boilers was not because some of these cast-iron boilers operate engine-driven fans, and whether in such cases he did not want a permissible pressure as high as 20 lb. per sq.in., and if so, whether he thought such pressure perfectly safe under steam and not water pressure. Mr. Child replied that he knew that a cast-iron sectional boiler was perfectly safe working on 65 lb. static pressure, as he had one in use at the present time.

Mr. Boehm insisted upon a direct answer to his question, in reply to which Mr. Child said that he did not recommend the use of cast-iron sectional boilers for high-pressure steam, such as 40 lb.

The report of the Committee on Uniform Boiler Specifications was read, as follows:

"We recommend that Sect. 8, part II, page 30, of the proposed recommendations by the A. S. M. E. be changed to read as follows:

"Safety valves having either the seat or disk of cast iron shall be allowed when riveted direct to the shell of boiler.

"Also, on same page, part II, Sect. 9, that there be inserted in the third line, after the word 'type,' the words 'or lever safety valve,' otherwise the said section to remain unchanged.

"On same page, part II, Sect. 11 be struck out and the following substituted:

"Fusible plugs, except as otherwise provided for, shall have an external diameter of not less than three-fourths of an inch pipe tap, and the banca tin shall be at least ½ in. in diameter at the smaller end, and shall have a larger diameter at the opposite end of the plug; provided, however, that all plugs used in boilers carrying a steam pressure exceeding 150 lb. may be reduced at the smaller end of the banca tin to $\frac{5}{16}$ in. in diameter.

"Fusible plugs, when used in the tubes of upright boilers, shall have an external diameter of not less than ⅜ in. pipe tap, and the banca tin shall be at least ¼ in. diameter at the smaller end and shall have a greater diameter at the opposite end of the plug.

"We further recommend, page 33, of part II, under Sect. 16, paragraph b, be changed to read as follows:

"Each boiler shall have three gage cocks, located as follows: the first gage cock to be located 2½ in. above the flue, the second gage cock to be located 4½ in. above, and the third 6½ in. above the flue.

"We further recommend that in part III, beginning at Sect. 1, all of Sect. 1 and all of the immediately following Sect. 2, down through the middle of page 186, be struck out, and that there be substituted therefor the present A. B. M. A. specifications covering materials, workmanship and dimensions, factor of safety, hydrostatic pressure and hanging or supporting the boiler.

"We further recommend that on page 208, Sect. 62 of part III, read:

"Manhole plates shall be of wrought or cast steel or cast iron."

A. B. CARHART called attention to the fact that the United States Government, while formerly calling for zinc plates in boilers on the supposition that they would prevent corrosion, had now withdrawn such specification because it had found that the zinc plates, while at first lessening corrosion, afterwards increased it, producing finally a much more intense corrosion than that which had been sought by their use to prevent. He hoped that the general public might not be misled by the action of the committee into thinking that zinc plates were unqualifiedly recommended.

At the executive session in the afternoon, the election of officers resulted in the re-election of former officers with the exception of Colonel Meier, W. C. Connelly being elected president, and in his response he pledged himself to renewed efforts for increased membership and furtherance of the objects of the association.

Among the social features of the convention were, on Tuesday evening, a reception with dancing and buffet refreshments, the grand promenade being led by Mr. and Mrs. George N. Riley; a sightseeing tour for the ladies, Wednesday morning; shopping and sightseeing tour to principal hotels and department stores, Thursday morning; banquet in the Astor Gallery, tendered by the Supplymen's Association, Thursday evening, and also a trip to Coney Island, with a dinner at the Hotel Shelburne, Friday.

George N. Riley was toastmaster at the banquet Thursday evening and kept the company in the best of humor. Among those who responded to toasts were the following:

Charles R. Lamb, representing the Merchants Association of the City of New York; W. C. Connelly, president-elect, A. B. M. A., Cleveland; D. J. Champion, treasurer, Supplymen's Association, Cleveland; Joseph Broderick, Muncie, Ind.; W. S. Bateman, Philadelphia, Penn.; James D. Farasey, Cleveland; Hon. Joseph Hartigan, Commissioner of Weights and Measures, New York City; Hon. G. A. Luck, chairman, Massachusetts Board of Boiler Rules; John T. Corbett, president, Supplymen's Association, Chicago; Miss A. B. Chute, Enterprise Boiler Co.

Mr. Bateman performed the pleasant duty of presenting to Mr. Champion a solid silver water pitcher.

F. B. SLOCUM, secretary of the Supplymen's Association, was presented with a solid silver service.

Decision as to place of next annual meeteing of the A B. M. A. is at present in abeyance, awaiting the action of the Executive Committee. It is understood that the matter of holding meetings possibly more frequently than once a year has been under consideration, and plans are on foot to secure in the future a larger attendance as well as increased membership.

Central States Waterworks Association

The eighteenth annual convention of the Central States Waterworks Association was held at Wheeling, W. Va., Aug. 25 to 27. The membership of this association is composed of waterworks engineers, superintendents and others interested in water works in the states of Ohio, Indiana, Illinois, Michigan, Kentucky, West Virginia and Western Pennsylvania. The principal technical papers and discussions of the convention were centered around purification and methods of utilizing the waters of the Ohio River and this subject was of especial local interest, as the city of Wheeling has recently adopted a water supply to be taken from the Ohio River by the Smith system of supply and filtration.

FILTRATION OF OHIO RIVER WATER

In a paper presented by C. B. Cook, city engineer of Wheeling, the author stated that it is necessary for nearly every community along the Ohio River to use the water from this stream for domestic and manufacturing consumption, as there are no other adequate sources of supply available.

The Ohio River has been well called "One thousand miles of sewer," for every hamlet, village, town and city from Pittsburgh to Cairo, empty its wastes from every source into the Ohio or its immediate tributaries, without the treatment, rendering the water unfit for human, animal, or manufacturing purposes.

The discharge from some of our manufacturing plants and some of the mines along the river and its tributaries has caused great inconvenience to all users of river water for expensive renewals from the pitting of the boilers and heaters or to the use of boiler compounds.

SYSTEM IS USE

There are several methods of purification and filtration in use by the various consumers of Ohio River water: the Well System, the Crib System, the Slow Sand System, the Rapid Sand or Mechanical System and the Smith System.

DRIVEN WELLS

The casings of the wells vary in diameter as do the size and number of the perforations used. The well system generally supplies a water that is hygienically pure but the water is nearly always harder than the river water, and in some cases, wells have been known to show contamination after some years of use, as well as to show a considerable decrease in flow. In the well systems water is taken either from wells drilled in the sand and gravel bars forming the bed of the river, or from sand and gravel banks along the river, and in either case, the wells secure a large percentage of ground water. The wells are usually drilled wells with the casing driven down to or into the bed rock a short distance and the bottom of the casing drilled with holes varying in diameter from one-quarter inch to one-half inch; some of the well systems have a solid piece of casing placed at the bottom of the wells and then have a perforated pipe above this solid piece. The water is allowed to flow by gravity from the wells to a pumping station well, and then lifted by steam pumps to the consumer or is raised by compressed air lifts out of wells into a sub-basin from which it is raised by steam pumps according to local conditions.

CRIB SYSTEM

The cribs are usually built of timber, brick or concrete near the bank of the river with the water flowing in and through the sand and gravel with which the crib has been filled, the river water filtering through the sand and gravel to the intake pipe of a pumping station and from there pumped to the consumer. Mud and silt are drawn through the sand and gravel, causing the crib to become clogged and the supply to be greatly, if not wholly, cut off. The crib is usually entirely submerged so that it is not readily accessible, and so cannot be cleaned. After contamination is found to exist, the only remedy is to abandon the crib or to cofferdam it and remove the sand and gravel. This is usually an expensive process, generally requiring the consumer during the execution of the work to use the raw river water and this clogs the distributing mains.

THE SLOW SAND SYSTEM

This is sometimes called the English system, as built in various parts of the country, and consists of filter units having an area ranging from one-half to one acre, the filter proper being contained in water-tight tanks, the walls and floors of which are constructed of concrete or brick. At the bottom of the filter tank is located the underdraining system, which takes the form of channels over which are laid large stones or boulders and then layers of graded gravel diminishing in size of particles toward the top. On top of these layers of underdraining material is the filter bed itself, which is composed of some three or four feet of carefully selected washed sand.

The filter is operated by allowing the raw water to flow on to the surface of the filter so that there is always a volume of water three or four feet deep when the filter is in operation. The discharge of slow sand filters does not at any time exceed about three million gallons per acre of filter surface per day. The mud, silt, clay and bacteria accumulating on the surface of the filter as it operates, increase in density and thickness until the filter refuses to pass the requisite amount of water. It then becomes necessary to shut down the filter, drain it and scrape off an inch or so of clogged material, following which operation the filter is refilled, the inlet and outlet opened and operation is resumed.

RAPID SAND OR MECHANICAL PROCESS OF FILTRATION

This system uses first a coagulating basin which is usually built of concrete, into which is pumped the raw water and into the raw water the coagulating chemicals are placed. The chemicals usually employed are sulphate of alumina and sulphate of iron, and sometimes lime applied to the raw water by various mechanical devices. The coagulating basin is built in two ways; first, a plain basin, and second by adding baffle walls inside the basin to retard the flow of the water through the basin, giving a longer period of sedimentation. If a plain basin is used, it should have a capacity of several days' flow; if the basin be baffled the capacity may be reduced to from eighteen to twenty-four hours' flow.

The coagulating chemicals form a glutinous substance to which the heavier particles in the raw water adhere and are precipitated to the bottom of the settling basin, from which they are drawn off into a drain. The water thus prepared then passes on through the filter beds which are usually built of concrete in units of from three to four million gallons capacity. At the bottom of the beds is located the underdraining system which takes the form of channels over which are placed layers of graded gravel diminishing in size toward the top. On top of this underdraining material is placed the filter bed of carefully selected washed sand. The water passes down through these filter beds at a rate of one hundred and twenty-five million gallons per acre of filter surface per day into a clear water basin and from this basin into the distributing system.

When these beds have become clogged with the materials in the water that have not been removed by sedimentation in the coagulating basins, the water is drawn off through the sewer and the clear filtered water is forced up and through the beds, stirring the gravel and sand, thoroughly washing it and the dirty wash water passes off into the sewer and the unit is again placed in commission. Compressed air is sometimes forced up through the washing water to agitate the sand for more thorough operation of the washing process.

THE SMITH SYSTEM

In this system strainer pipes are placed below a filtering bed in the river. The system is not applicable to all locations, but must have the natural facilities in the form of a proper gravel and sand bed in the river.

ADAPTABILITY AND EFFICIENCY

All the systems of filtration in use along the Ohio River have their strong adherents and their opponents. No system has a general adaptability, but each locality presents its individual problem, and these problems must be met by the most careful scientific study so that they may be solved in an economical, hygienic and conclusive manner. Because a system of filtration may be appropriate to one locality is no reason why it will suit another. None of the systems are fool-proof but must be operated with care. To guard against imperfect operation the filtered water should be examined at regular and at frequent intervals for the raw water changes its character from long periods of draught to times of freshet and at times changes occur very suddenly.

In a well system where the water passes from the wells to the well at the pumping station, where the water ends of pumps are submerged, the analyses frequently show high counts of bacteria and frequently show coli. It is quite possible that the raw water is leaking into the pump well contaminating the water taken from the filter well. It is also true that where a rapid sand or mechanical filter is in use there are frequent complaints of disagreeable taste and odor in the water and others have the red water plague, and give trouble from clogging of pipes connected with plumbing fixtures all of which result from bad design or neglect in the handling of the plant, and are entirely preventable.

DISCUSSION

In discussion of the paper, Dr. S. L. Jepson, secretary of West Virginia State Board of Health, stated as the result of his investigations covering some years, that the mechanical filtration system was the best available for Ohio River water, in which conclusion he believed that hydraulic engineers of reputation not only in this country but in Europe would coincide. He characterized as a "monumental blunder" the action of the city council of Wheeling in asking the people generally to express their preference by straw vote as to what system of filtration should be adopted; this he considered a matter properly of scientific determination only, and a matter about which laymen cannot expect to know, and even the best informed know none too well. He stated that eight years ago the Government officials had condemned all plans of natural sand filtration for Wheeling.

J. C. Martin, president of the association, spoke at some length upon the general question of the importance of filtration and cautioned the citizens of Wheeling that it would be well to go slow before launching into an investment which would no doubt represent as large an indebtedness as they could carry comfortably for some time to come. Before entering into such an expenditure it would be well to carefully consider and be guided, not by uninformed opinion or bias but to follow the recommendations of scientifically trained experts who had made these matters a life-time study. While he did not wish to take any sides in a local controversy, he believed that it would be unwise to adopt any plant the mechanism of which would be concealed in the bed of the river and its operation not susceptible of frequent examinations from time to time as occasion might arise to find if it was in good order, and whether it was doing the work it was intended to do, which inspection could not be made without uncovering the bed of the river at great and almost prohibitive expense.

SMITH SYSTEM AT PARKERSBURG, W. VA.

L. E. Smith, patentee of the Smith system, in a paper on "Filtration and Purification of Ohio River Water" described the system devised by the author. It consists of laying horizontal strainer pipes five or six feet below the bed of the river and connecting a gravity line to the intake at the pumping station, so the water may flow by gravity to the pumps. In the plant now in operation at Parkersburg, W. Va., the beds comprise five units, each unit consisting of two parts, the parts and units being separated 25 ft. by unexcavated parts of sand bar about 450 ft. from the West Virginia shore of the Ohio River. An 18-in. gravity line leads from each of the units to a valve chamber on the shore, the effluent entering a manifold, to which is attached the pipe leading to the pumps.

The guaranteed capacity of the plant is 4,000,000 gal. daily. There are 160 strainers, 5 in. in diameter by 15 ft. long, each containing 9100 slots. The strainers are placed in an excavation 5½ ft. deep, covered with coarse screened gravel to a depth of 15 in., and over this bed is a layer of fine gravel. Water passes down through the bed of sand at the rate of about 5 in. per hour. Provision is made for backflushing by which any unit may be separately backflushed of pollution without interfering with the regular operation and use of the remaining units.

During the discussion of the paper the author stated he believed the system to be the best possible where conditions were favorable; there must be a suitable bed of gravel to insure purification and clarification of the water.

⁂

The Public Hearing of the Boiler Specifications Committee

The work of the Boiler Specifications Committee marks one of the most important undertakings of the American Society of Mechanical Engineers.

During the past few years, the introduction of boiler inspection laws in various states and cities has aroused the necessity for the establishment of uniform requirements, and the efforts of the committee in this direction have been generally favored and supported. It has been found that the most important interests are in favor of the best material and construction known, and the letters that have been received, particularly from those abroad, quite generally indorse the position that has been taken by the committee.

The basic idea of the committee's work is the formulation of a standard of the highest requirements, thereby reducing the great loss of life and property in the United States from boiler explosions and derangements, which are for the most part preventable. It is the intention also to create a standard which, it is hoped, will ultimately be adopted by the Federal Government and state governments not now having boiler regulations, and, through uniform legislation, to produce such a condition of affairs that a boiler built for any one state will be acceptable in any other.

Where state legislation has been enacted, it is hoped that it will be modified to conform to the society's model.

The preliminary work of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for the Care of Same in Service, which was completed last February and placed in the form of a tentative report, was issued in an edition of 1500 for a preliminary study, and was submitted to recognized authorities throughout the civilized world, including nonmembers of the society as well as members; it was sent to boiler manufacturers, prominent steel manufacturers, insurance companies, boiler users, consulting engineers, operating engineers, and all who are known to have special knowledge of the boiler business. With each copy was sent a request that the recipient should take out whatever was considered inadvisable and add whatever would further safeguard human life and property.

At the St. Paul-Minneapolis meeting, much interest was shown in the work of the committee. This was not considered as a report, but a topical discussion of some of the more important phases of steam boiler legislation was held, and many of the points in boiler practice on which there is a difference of opinion were considered. There had been a conference at Chicago, on Monday, June 15, between representatives of the committee, the Association of Steel Manufacturers and the National Tubular Boiler Manufacturers Association, at which the discussion was devoted largely to the steel specifications desired. This discussion was continued at the opening session of the spring meeting on Wednesday morning, June 17, and was transferred later to a separate meeting room, where it was continued the greater part of the day. The committee has sought in every way to secure the most full expression of opinion. The necessity for a careful study of the more important factors involved was emphasized by the committee, and the result of the discussion was a resolution calling for a public hearing in New York in September, as follows:

> Resolved, that on Sept. 15, 1914, the committee hold, in the rooms of the American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., a hearing of all interests concerned on the preliminary report of the committee appointed to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of same in service, and that those desiring to participate in the discussion present their criticisms and suggestions in writing prior to Aug. 15.
>
> Resolved, that in addition to invitations, notification by publication in the technical press be given to the hearing.

Carrying out the policy of the committee and the society in all of its determinations, invitations have been sent out to the following associations and engineering organizations known to be interested in the matter of standard boiler specifications:

American Boiler Manufacturers Association,
American Institute of Steam Boiler Inspectors,
American Railway Master Mechanics Association,
American Society of Heating and Ventilating Engineers,
American Society of Testing Materials,
Association of American Steel Manufacturers,
City of Chicago, Department of Boiler Inspection,
City of Detroit, Office of Chief Boiler Inspector,
City of New York. Department of Boiler Inspection,
City of Philadelphia, Department of Boiler Inspection,
Committee on Relation of Railway Operation to Legislation,
Indiana State Bureau of Boiler Inspection,
Industrial Commission of Wisconsin,
Interstate Commerce Commission,
Marine Engineers Beneficial Association,
Massachusetts Public Service Commission,
Massachusetts Board of Boiler Rules,
Montana State Board of Boiler Inspection,
National Association of Boiler Manufacturers
National Association of Cotton Manufacturers,
National Association of Stationary Engineers,
National Association of Thresher Manufacturers,
National Bureau of Standards,
National Council for Industrial Safety,
National Tubular Boilermakers Association,
New York State Commission on Uniform State Laws,
Ohio State Board of Boiler Rules,
Public Service Commission, Second District, New York State,
State of Illinois,
State of Maryland,
State of New York,
State of North Carolina,
State of Pennsylvania, Department of Labor and Industry,
State of Virginia,
U. S. Board of Supervising Inspectors of Steam Vessels,
U. S. Bureau of Steam Engineering,
U. S. Department of Commerce.

Most of the organizations named have accepted the invitation.

These organizations were invited to be present or to have representation at the hearing, which will be held in the rooms of the society, in New York, at 10 a.m., Tuesday, Sept. 15, and also, in so far as possible, that all who had not already done so, prepare and send a statement in writing previous to the hearing, to assist in the deliberations.

The foundation of these rules is the boiler law of Massachusetts, which has been enforced for some time and which has recently been adopted by the state of Ohio, the city of Detroit and the city of Manila, in the Philippine Islands. Several of the other states are now considering the adoption of standard rules regulating boilers and other pressure vessels. In the six years that the Massachusetts rules have been in force, over 8300 boilers have been constructed to that standard, and boiler explosions and derangements have been reduced to a minimum.

Much credit is due to the committee for its tireless efforts in preparing the tentative report, in collating the enormous amount of data embodied in the voluminous recommendations on which the tentative draft was based. The work has involved much self-sacrifice on the part of the members, particularly John A. Stevens, chairman, whose extensive experience as a member of the Board of Boiler Rules of the State of Massachusetts, in developing and inaugurating the Massachusetts standard, has been turned to advantage in the work here undertaken. The other members of the committee to whom much credit is also given are W. H. Boehm, R. C. Carpenter, Richard Hammond, C. L. Huston, E. D. Meier and E. F. Miller. This work, which is borne exclusively by the committee members and by the American Society of Mechanical Engineers, is for the benefit of the people through the protection of life and property and of the boiler industry at large. It is national in character and its effect will be felt not only by the manufacturing interests in easier conditions for selling, but also will be of similar benefit to the users, as it will enable them to secure boilers more promptly and at less cost for a safe boiler.

PERSONALS

Henry D. Shute has been elected treasurer of the Westinghouse Electric & Manufacturing Co., Pittsburgh, Penn., to succeeed T. W. Siemon, who recently resigned to accept the position of secretary-treasurer of the Union Switch & Signal Co., Swissvale, Penn.

Mr. Shute was born at Somerville, Mass., and is a graduate of the Massachusetts Institute of Technology. He has been with the Westinghouse electric company since 1893, first in the testing department, then in erecting and laboratory work, and in the engineering department until 1898, when he was transferred to the commercial department. In 1903 he was made assistant to Vice-President L. A. Osborne, in which position he was particularly active in developing the heavy electric traction and single-phase railway work. In 1910 he succeeded Walter McFarland as acting vice-president of the company.

Mr. Shute is a member of the American Institute of Electrical Engineers, National Electric Light Association, Engineers Club of New York, is a director of the Pittsburgh Chamber of Commerce, and is closely identified with a number of other technical and social organizations.

Truman P. Gaylord, district manager of the Westinghouse Electric & Manufacturing Co. at Chicago, has been elected acting vice-president to succeed H. D. Shute, now secretary-treasurer. Mr. Gaylord was born at Shelby, Mich., and graduated from the Armour Institute of Technology.

He was engineer of underground construction during the World's Fair at Chicago, 1892-3. Then he became assistant professor of electrical engineering in the Armour Institute until 1898, when he became electrical engineer for the Commonwealth Edison Co. of Chicago.

From 1899 to 1902 he was a salesman for the Westinghouse Electric & Manufacturing Co. Then he was made district manager of the company in Chicago.

Mr. Gaylord is a member of the American Institute of Electrical Engineers, the National Electric Light Association, and is closely identified with a number of other engineering societies.

NEW EQUIPMENT

ATLANTIC COAST STATES

Fire recently destroyed the electric-light plant at Mount Vernon, Maine, owned by R. H. Jacobs. Loss, $10,000.

The Central Maine Power Co., Waterville, Maine, plans to build a new fireproof station to replace the one recently burned. F. H. Mason is Ch. Engr.

Bids will be received by Dr. Carl J. Hedin, Supt. of Maine School for Feeble-Minded, West Pownal, Maine, until noon, Sept. 18, for constructing a power plant and transmission line. Arthur B. Fels, 60 Union St., Portland, is Engr.-in-Charge.

Bids will be received until 2 p.m., Sept. 28, by E. L. Williams, Cornell University, Ithaca, N. Y., for the construction, heating and plumbing and electric work for the new drill hall for Cornell University.

The Atlantic City Electric Co., Atlantic City, N. J., has secured a permit and will soon call for bids for the construction of a power house costing about $9000.

Fire recently damaged the power station of the Philadelphia Electric Co., Robbins Ave., Philadelphia, Penn. Loss, $10,000.

WEST OF THE MISSISSIPPI

Fire, Aug. 24, destroyed the Adel Light & Power plant, Adel, Iowa. The estimated loss is $50,000.

At a recent election, the citizens of Aurelia, Iowa, voted in favor of a bon dissue for the construction of a municipal electric-light plant. The estimated cost is $7000.

Press reports state that the Town Council, Aurora, Minn., cotemplates erecting a municipal electric-light plant.

A municipal electric-light plant, costing $10,000, will be constructed at South Sioux City, Iowa (Sioux City post office).

Bids will be received by the State Board of Control, St. Paul, Minn., until noon, Sept. 15, for power-plant equipment for the St. Cloud State Reformatory, St. Cloud, Minn. The Charles L. Pillsbury Co., Metropolitan Life Bldg., Minneapolis, Minn., is Engr.-in-Charge.

The citizens of Kansas City, Kan., at a recent election, voted to issue $450,000 in bonds, the proceeds to be used for making improvements to the municipal electric-light plant. The following equipment is needed: Boilers, a 3000-kw. turbine, coal and ash-handling machinery, superheaters, steam and water piping. The estimated cost is $200,000.

The City Council, De Witt, Neb., is considering plans for the establishment of a municipal electric-light plant to cost $15,000.

The Wild Cat Mining Co., White Oaks, N. M., contemplates building an electric power plant and a power transmission line to its mines in Nogal Cañon and to Carrizozo. A. B. Graham, J. H. Fulmer, Jr., and W. H. Tupper, all of Mishawaka, Ind., are interested.

The Auburn Gas Co., Auburn, Wash., will construct a gas plant, estimated to cost $40,000. J. L. Veach is Mgr.

On Aug. 29, fire destroyed the power plant of the Northern California Power Co., Redding, Calif. The town is without light or power. Loss about $20,000.

The Mount Whitney Power Co., Tulare, Calif., will build a reinforced-concrete substation. H. A. Kluegel, Visalia, Calif., is Ch. Engr.

POWER

Vol. 40 NEW YORK, SEPTEMBER 22, 1914 No. 12

The Job
That Wanted A Man--A True Story

"Hello, Mr. Veers? This is Mr. Ponce of the Ponce Steel Co. Say, Veers, we need a chief engineer for our Du Twain Works. You've been an assistant there; you know the plant. Would you like to take the job?"

"Thanks, Mr. Ponce; but I've a good place here. I greatly appreciate your thoughtfulness for calling me up, though."

"Job pays $1800 a year, Veers, and there's two weeks' vacation, with pay in advance. We'll do better. All depends on the quality of the man. Can't consider it, eh? Well, can you recommend a man that's capable of the job? You know a lot of engineers."

"Don't know of a good man that's idle, one that I could send you, Mr. Ponce, but I'll see what I can do. Don't mention it. Good-by."

Veers was silent for a full three minutes, then lifting his head with a jerk, exclaimed:

"Beats the devil, doesn't it? I know at least three hundred men in this city—all fine chaps, personally—that'd jump for that job like a hungry dog for a bone, but I dare not send one to the place!"

"*Dare* not send one? Why?" I asked in amazement.

"Y'see, it's an alternating-current job—2400 volts to the board and transformers, then 240 to the motors in the scattered buildings. It's an up-to-the-minute plant; runs day and night. A moment's interruption of service would throw the management into nine catfits. They're exacting, but as square as a Quaker. They're willing to pay for the goods, but they *want* the goods.

"Our boys in this town are not up on the A. C. stuff. They'd fall as sure's my name is Veers. Then I'd get in wrong. Too bad! But it's mostly their own fault. Goodness knows, the sources from which to learn about running an A. C. plant are many.

"I help these boys all I can—always put better jobs in their way—but some other fellow's going to get this one."

Virginian Power Co.'s New Steam-Turbine Plant

By Warren O. Rogers

SYNOPSIS—The present 20,600-kv.a. output of the plant will be consumed by coal-mining operations for cutting, hauling, hoisting, ventilating and pumping. The plant is constructed on the unit plan, each generator unit having its own boilers; combinations can be made, however. Coal is delivered to the boiler-house bunker by a skip hoisting system and cable-drawn cars, which automatically unload into the bunkers. Coal is discharged from the bunker to the mechanical stokers of the twelve 600-hp. water-tube boilers.

⁂

The project of generating electrical energy at a central power plant to be used for operating the hundreds of coal mines of the Kanawha and New River districts within a radius of 50 miles has just been consummated by C. O. Lenz, of New York, who designed and constructed the new 20,600-kv.a. capacity steam-turbine power plant of the Virginian Power Co., at Cabin Creek Junction, W. Va.

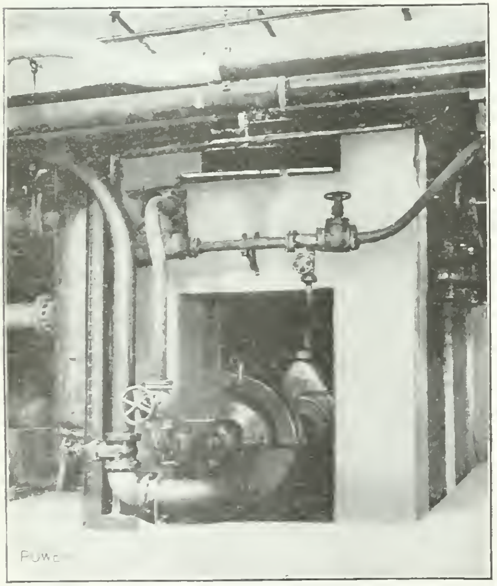


Fig. 1. Condenser and Turbine Driving Pump

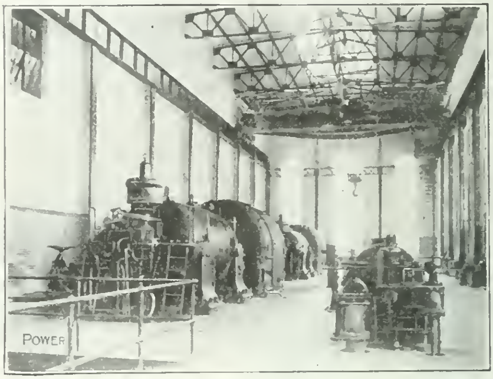


Fig. 2. Turbine Room of the Virginian Power Co., Cabin Creek Junction, W. Va.

The plant is built on an 11-acre plot of land, owned by the company, and is on the west bank of the Great Kanawha River, and on the main line of the Chesapeake & Ohio R.R., which affords delivery of coal from the Cabin Creek district. An idea of the number of mines in the 50-mile radius from the power house is had when it is known that on the Cabin

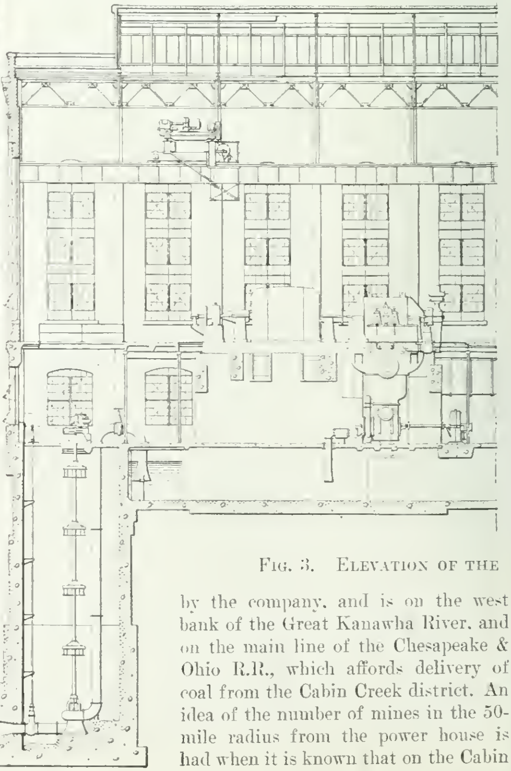


Fig. 3. Elevation of the

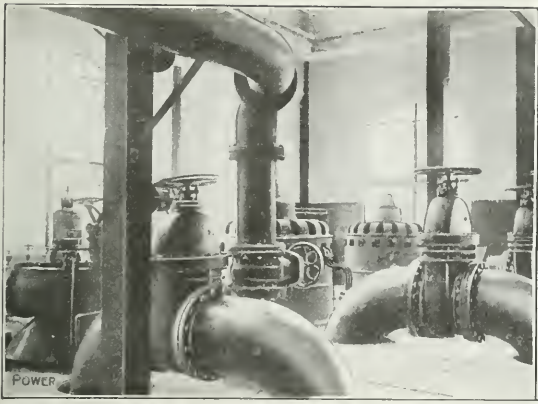


Fig. 4. A View of the Vertical Turbine and Motor-Driven Pumps

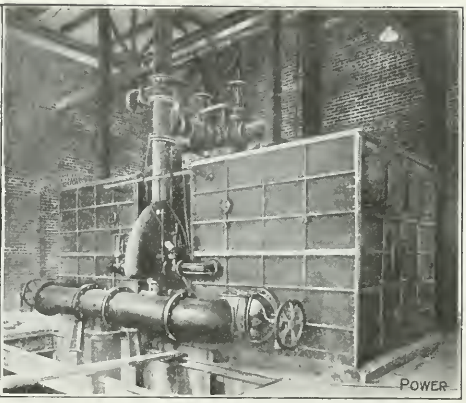
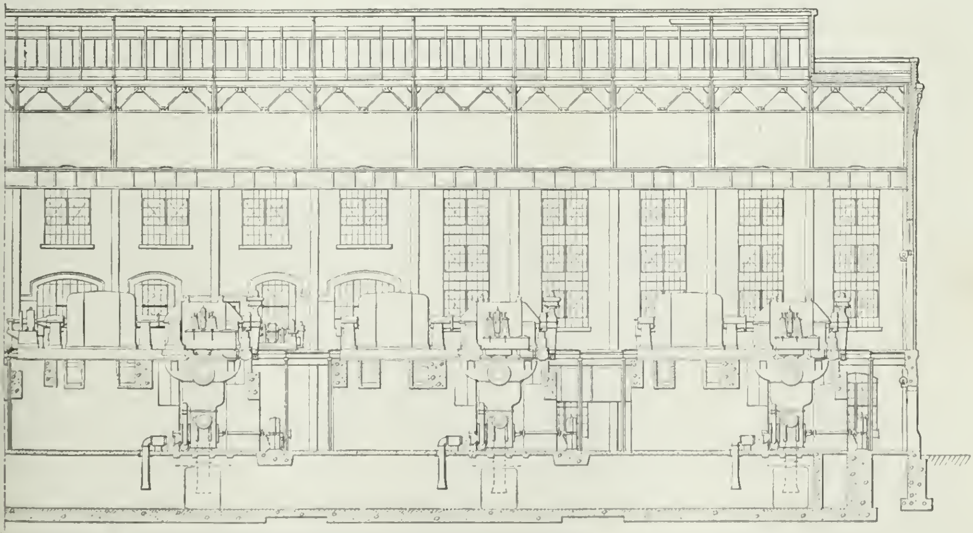


Fig. 5. The Two 10,000-Hp. Open Feed-Water Heaters

Creek branch of the railroad there are 52 mines in a distance of 50 miles. The mines which the plant will serve operate on a 24-hr. basis and a load factor of 35 per cent. is expected at the power plant.

Building

The turbine room is 237 ft. long and 50 ft. wide. The two boiler rooms are in wings built at right angles to the turbine room, which leaves an open court between them. The boiler rooms are each 140 ft. long by 92 ft. wide.



Turbine Room, Showing Present and Future Turbo-Generators

The superstructure is built on a concrete foundation and base courses. The superstructure is a self-supporting skeleton steel frame encased with brick, which are pilastered at the columns with a cornice of concrete and brick around the building. Both the boiler- and the turbine-room walls are broken by spacious windows, the frames and sashes of which are steel. As the boiler and turbine buildings have a ground floor at 6 in. above grade, a basement has been eliminated. The main operating floors of the boiler and turbine rooms are 17 ft. 2 in. above the ground floor, which permits of natural light to all parts of the building, also free ventilation.

The roof is concrete slabs reinforced with "Hyrib" and pitched and valleyed to low points for drainage. To insure tightness, four-ply "Hydrex" roofing is used for a roof covering, bolted slag being spread over the roof covering to prevent the compound from flowing. All floors are steel frames holding reinforced-concrete slabs, and are capable of carrying a gross load of 400 to 600 lb. per sq.ft.

Turbine Room

The present equipment consists of two 10,300-kv.a. double-flow turbo-generators, delivering three-phase, 60-cycle, 6600-volt current when running at 1800 r.p.m.

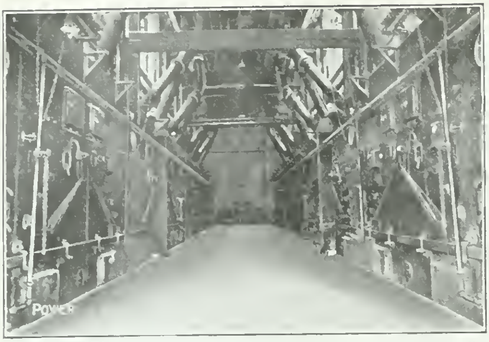


Fig. 6. Firing Aisle in No. 1 Boiler Room

Each is equipped with a 90-kw., 125-volt, direct-current, direct-connected exciter. There is also a 100-kw., 125-volt, 2400-r.p.m., single-stage turbine-driven exciter unit as a standby. These are shown in Fig. 2. The two turbo-generators which will be put in when the demand for electrical energy warrants will not have self-contained exciters, there being sufficient direct-current capacity in the three present exciters.

The station can be operated on the unit plan, that is, any one turbine with its boilers, generator and its step-up transformers and feeders independently; interconnections are possible, however.

The main turbine units are connected to a suspended No. 20 Leblanc condenser, the pumps for which are driven by a 250-hp. reëntry steam turbine at 700 r.p.m. These are on the ground floor, as shown in Fig. 1. The condenser is between the turbine foundation columns, with the turbine outside. This allows for a connecting-shaft long enough to permit movement of the condenser with temperature changes.

An abundant supply of clean condensing water and boiler feed is obtained from the river. Screens prevent débris entering the pumps. From the intake, the water flows through two 28-in. pipes to a small surge basin, from which the water flows by gravity to the main water-supply pumps. These are in a pit 53 ft. below the pump-room floor, which is on the ground level and at the river end of the turbine building, as shown in Fig. 3, which is an elevation of the present and contemplated turbine room.

There are three main pumping units, Fig. 4. Two are 24-in. vertical shaft pumps, with a capacity of 17,000 gal. per min., running at 385 r.p.m., driven by 320-hp., 440-volt induction motors. The other is an 18-in. pump with a capacity of 8500 gal. per min., at 550 r.p.m., driven by a 165-hp. vertical steam turbine. These pumps discharge into a concrete flume which extends the length of the building under the turbine-room floor, and from

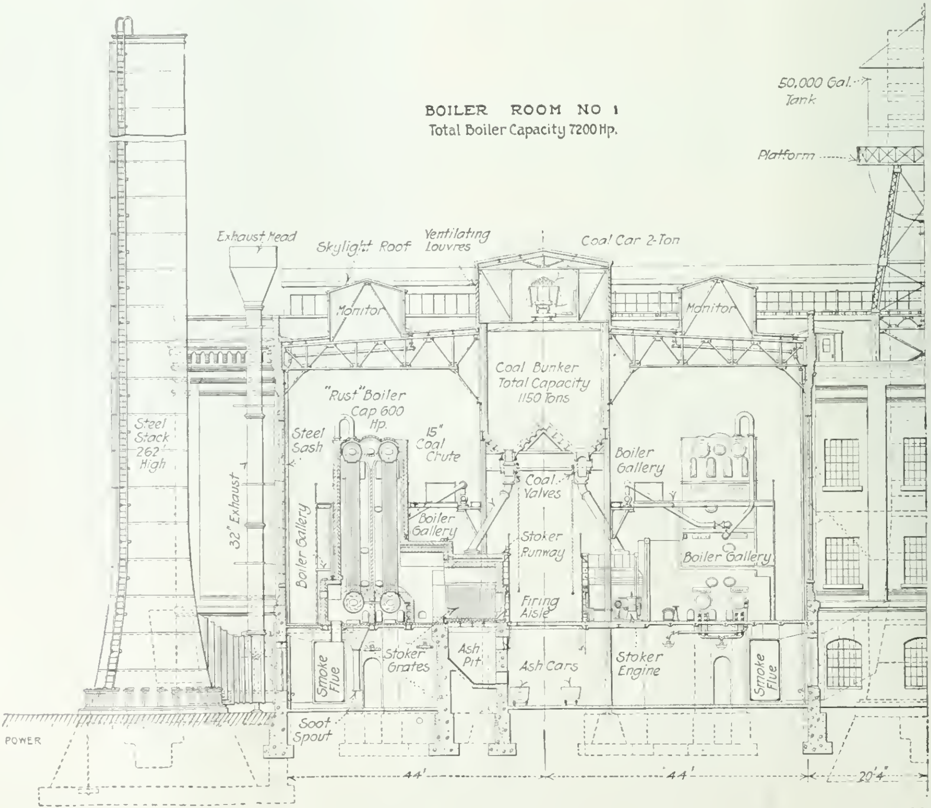


Fig. 7. Elevation of the Two Boiler Houses, Each to Contain Twelve 600-Hp

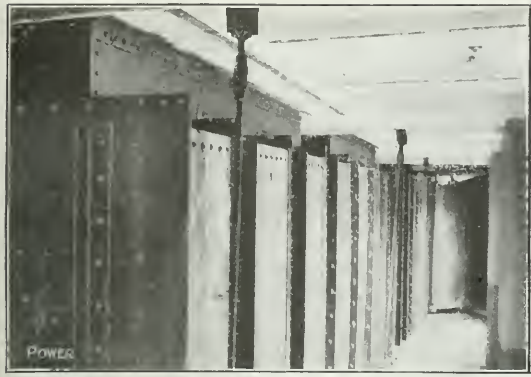


Fig. 8. Smoke Flue below the Boilers

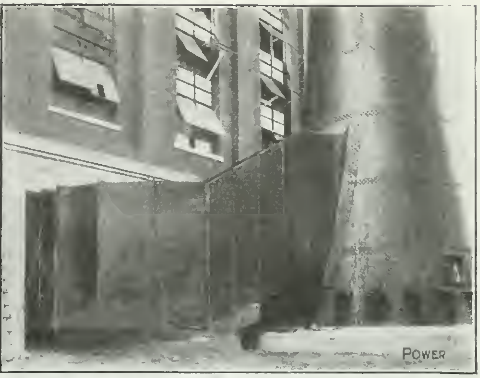
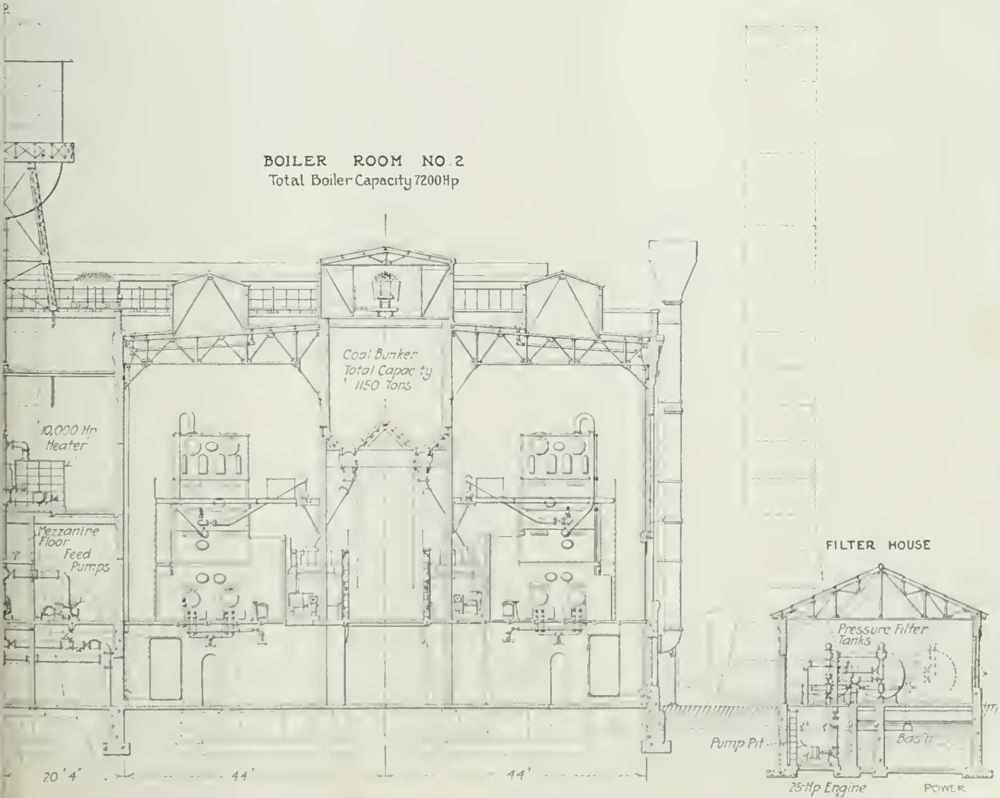


Fig. 9. Smoke-Flue Connection to the Chimney

which the injection water is pumped to the condenser.

Alongside of the intake flume is a discharge duct into which the condensers discharge, and which also receives the overflow from the intake flume. The discharge from the condensers flows to a concrete discharge tunnel, which empties into the river just below the intake portal. As the flow of the river carries the water down stream, this does not affect the condensing water temperature.

At the boiler side of the wall dividing the condenser from the ashpit rooms are two double-suction, 6-in. horizontal, centrifugal pumps, each having a capacity of 1200 gal. per min. One is directly connected to a 75-hp., three-phase, 60-cycle, 440-volt induction motor and runs at 1760 r.p.m. The other is driven by a single-stage steam turbine at 1760 r.p.m. These pumps elevate water from the intake tunnel to a 50,000-gal. tank on the roof



Boilers. The Arrangement of the Boiler Feed Pumps and Heaters Is Shown

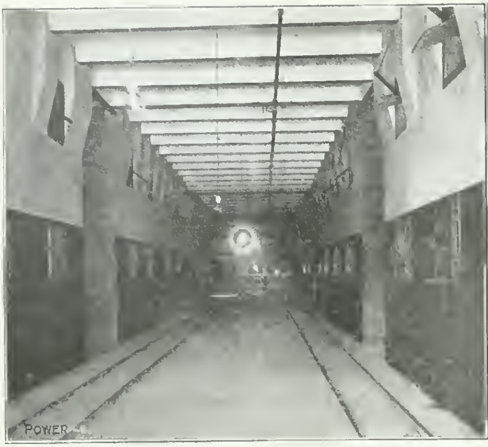


Fig. 10. Alley between the Ashpits

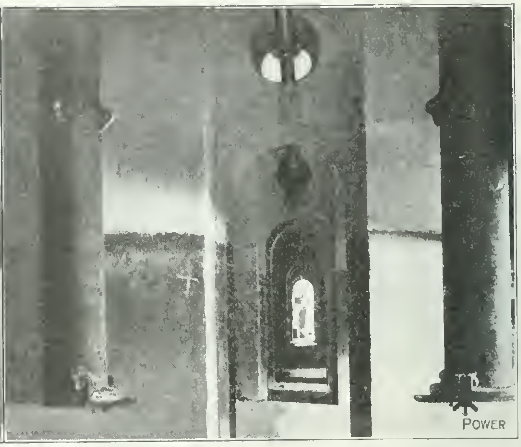


Fig. 11. Cinder Chutes under the Boilers

either directly or by pumping through pressure filters. The filtered water is for boiler feed makeup and general house service.

Boiler Feed Pumps

The two 10,000-hp. open feed-water heaters and purifiers, Fig. 5, are in a room between the two boiler-room bays. Below, on a level with the boiler-room floor, are two 400-gal. per min. double-suction, triplex, turbine-driven boiler feed pumps. Each runs at 3000 r.p.m. and delivers water to the boilers at 225 lb. pressure; the turbines are of 96 hp. each. This arrangement gives a good head to the feed pumps.

Boilers

As already stated, the boiler plant, Fig. 6, will be in two separate houses. The one boiler house at present completed contains six batteries of two boilers each. These

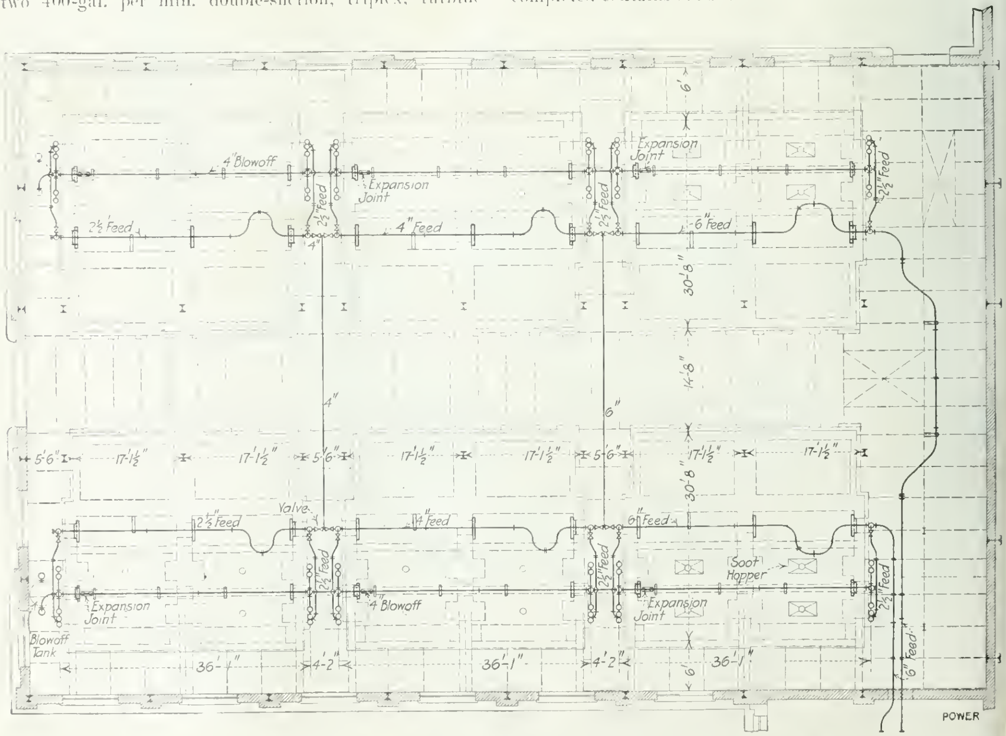


Fig. 12. Arrangement of Boiler Feed Pipes

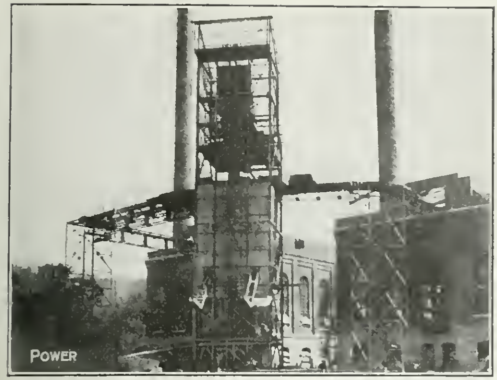


Fig. 13. Coal- and Ash-Handling Tower and Cable-Car Runway

water-tube boilers are of 600-hp. capacity, or 7200 hp. total. Each boiler has a total effective heating surface of 5882 sq.ft. This boiler capacity gives a ratio to the combined turbine capacity of approximately 1 to 2.9. The boilers have dutch oven furnaces, which are equipped with mechanical stokers, each 8x12 ft., or 96 sq.ft.; this with the back plate gives an effective grate area of 120 sq.ft. per boiler, or a ratio of 1 to 5 to the boiler rating. As each boiler has 5882 sq.ft. of heating surface, the ratio of grate surface to heating surface is 1 to 49.

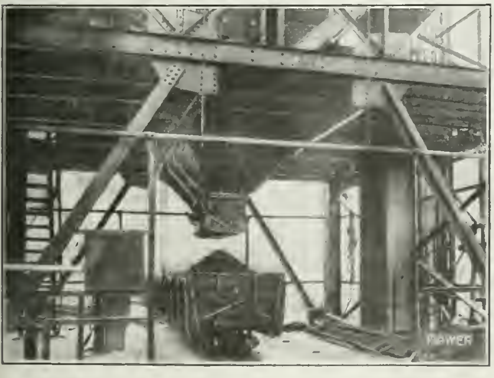


Fig. 14. Cable Car, Loaded with Coal, on Track Scale

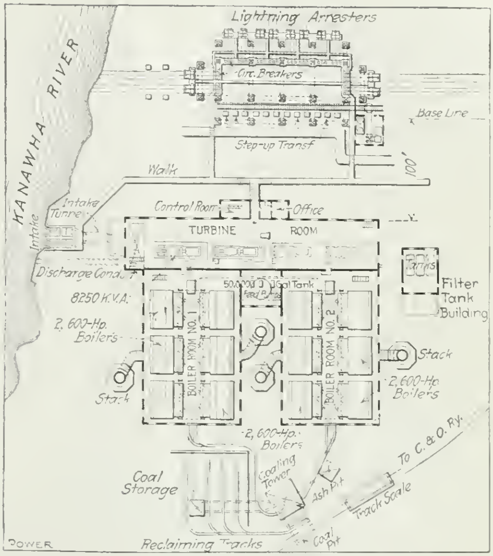


Fig. 15. General Plan of the Power-Plant Layout

Natural draft is used in the furnaces, with which the furnace and stokers can be forced to 200-per cent. rated capacity for peak loads.

The boiler house is divided into two sections, Fig. 7, a row of six boilers on a side, with a firing aisle between. The boilers have superheaters, which superheat the steam 50 deg. A pressure of 185 lb. is carried.

Each row of six boilers has a self-supported steel stack, brick lined from top to bottom. The stacks are 262 ft. high and have an inside diameter of 11 ft. 4 in., giving 101 sq.ft. of cross-sectional area.

The boilers are connected from the last pass to a lined steel smoke flue, Fig. 8, which is under the rear of the boiler on the ground floor. Midway of the building, the flue goes out through the wall to the stack, Fig. 9. This arrangement eliminates all sharp turns in the passage

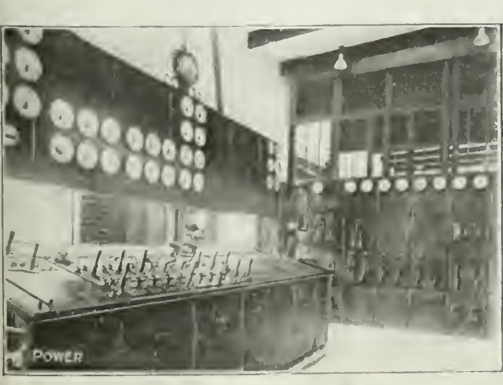


Fig. 16. Control Room

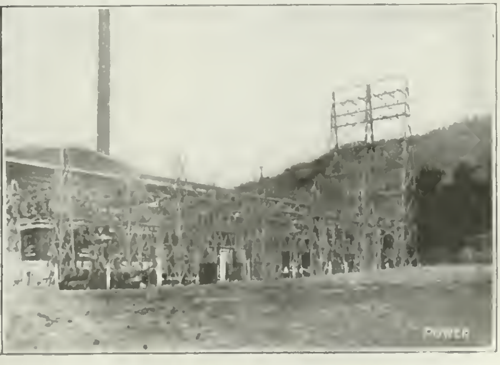


Fig. 17. Outdoor Transformer Station

of the flue gases to the stack and puts the flue below the boiler room out of the way.

The setting of the boilers is arranged with fire-brick lined ash pits, which are on the ground floor of the boiler house. They are made with a sloping bottom, so that the ashes can be raked out into a one-ton ash car, which runs on tracks in the alley between the two rows of ash bunkers, Fig. 10. The ashes will at first be used for filling in around the plant, but later, when not required for the purpose, will be wheeled to the ash track hopper at the coal and ash elevator out in the yard and elevated by skips to an ash bunker in the tower.

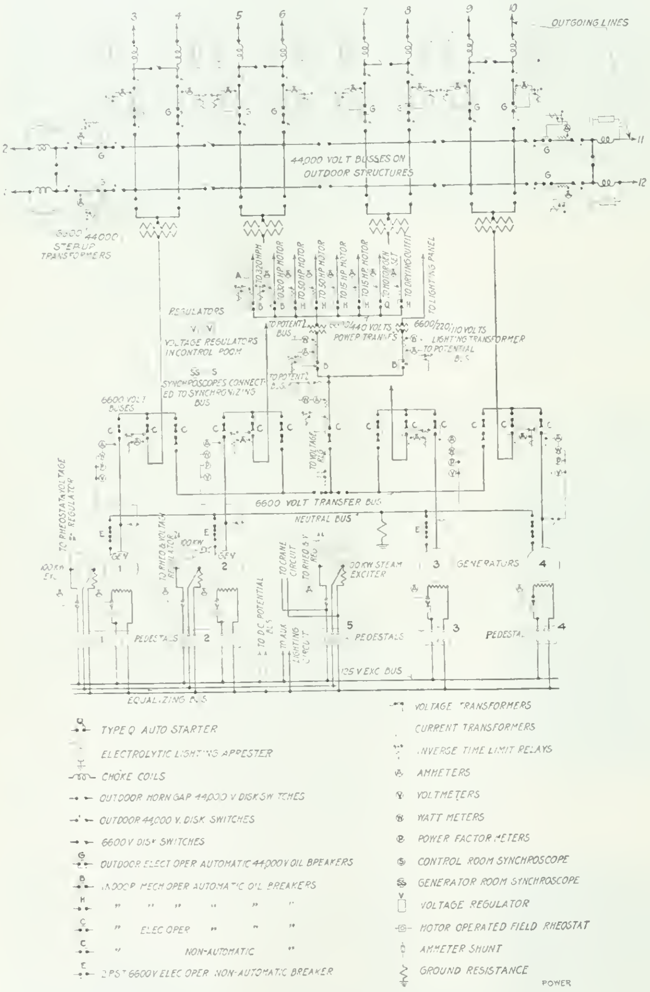


Fig. 18. Wiring Diagram of the Power House

At the back of the boiler ashpits are two cinder bunkers into which the cinder falls in passing through the two passes of the boiler. Each has a sealed discharge chute, which makes cleaning out comparatively simple. The chutes are shown in Fig. 11, which is a view through the alley under the boilers.

At the far end is shown the blowoff tank, which discharges into the river. It is connected to a second tank piped to the other row of boilers by a vent pipe, which is run to the atmosphere.

The arrangement of the boiler feed line is shown in Fig. 12. Each set of six boilers is supplied by a main 6-in. line, reducing at the last boiler to 2½ in. Besides the regular feed connection, a 2½-in. branch pipe is tapped into the main feed line, and is connected to the blowoff line with suitable control valves between. This gives an emergency feed for each boiler. In addition, there are a 4- and a 6-in. line between the two main feed lines, so that any combination can be made to get water to all boilers if either main feed line fails.

Coal-Handling Apparatus

Above the boilers and firing aisle in each boiler room is a steel, concrete-lined coal bunker 120 ft. long. It has a capacity of 12 tons per lin.ft., or a total capacity of 1440 tons. All coal is handled by a hoist contained in a structural steel tower, 124 ft. high, Fig. 13. This houses a concrete ash bunker, concrete-lined coal-receiving hopper, crushing rolls and machinery for operating a double skip elevating system. At the bottom of the tower are two concrete receiving hoppers. One is for coal and holds 60 tons. The other is of the same size and is to receive the ashes from the ashpit cars when wheeled from the boiler house.

Coal is switched over the coal hopper and discharged into it. The hoisting skips lower to a point below the discharge spout of the hopper, so that the coal runs into them by gravity, the flow being controlled by an S-gate operated by a lever from the operator's platform. Before the gate opens, however, a movable chute is moved out with the same operation, so no coal is dropped into the skip pit when the gate is being opened and closed.

The skip being charged with coal, is hoisted by a motor drive to the top of the tower, when the skip is automatically dumped, its contents going to a double set of crushing rolls, from which the crushed coal goes to a receiving hopper and from which it is delivered into cable-drawn railway cars. When being filled, these cars are on a track scale, Fig. 14. Each car has a cable grip which is tightened on the endless cable by a handscrew. The cable, which is kept taut by a counterweight suspended at the right of the tower, runs around guide pulleys at the curves and on rollers on straight runs from the tower to the coal bunker in the boiler house, at the left of Fig. 13, and returns through the other boiler house.

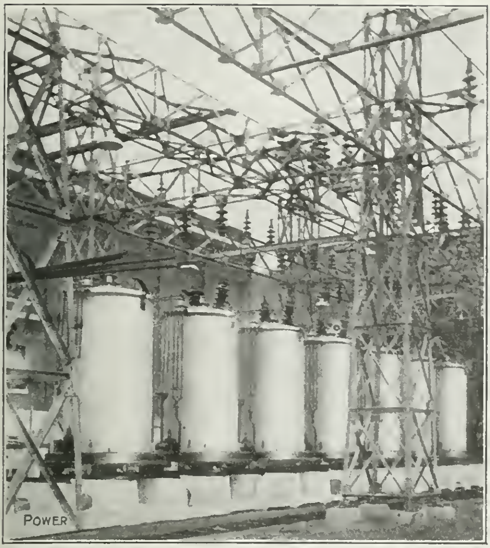


FIG. 19. TRANSFORMER AND CONCRETE FOUNDATIONS

A tripper, which can be placed at any desired point over the bunkers, automatically dumps the car load. A single pull of a lever resets the side doors of the car ready for a new load. From the bunker, the coal is delivered to the stokers through chutes, of which there are two for each boiler, with one bunker outlet. The maximum capacity for hoisting, crushing and conveying lump coal is 150 tons per hour.

As soon as conditions permit, a coal-storage space will be provided in the yard. Reclaiming tracks will run to this supply, which when needed can be loaded into cars and dumped into the coal hopper for hoisting to the crushing rolls. Fig. 15 is a plan view of the plant, showing the coal-storage area on the near side.

The present structures are ample in size for double the rated generating capacity of the present equipment. The foundations for the two stacks for the second boiler house are already built. When the additional equipment is in, the plant will have a turbine capacity of 41,200 kv.a. and a boiler output of 14,400 hp.

ELECTRICAL CONTROL

The control room is on the front of the turbine building and level with the turbine-room floor. Here are the bench board and measuring instruments, Fig. 16, for remote control of the low- and high-tension switches, a chief engineer's office and a chart room. On the ground floor are the storage batteries, power and lighting transformers and toilet room. All low tension oil switches and busses are in concrete cells on the ground floor of the turbine building. A wiring diagram of the power house is shown in Fig. 18. All high-tension apparatus is outside the building. The steel supporting frames, transformer, disconnecting switch, choke coils, circuit-breakers and electrolytic lightning arresters are shown in Fig. 17. There are seven 2750-kv.a. outdoor-type transformers, which raise the voltage from 6600 to 44,000 volts. They are single-phase, 60-cycle, and their high- and low-tension sides are connected delta. The transformers, Fig. 19, rest on a wheeled platform, which is supported by rails on concrete stringers laid on a concrete foundation. A track runs in front of the transformers to a repair house at one end of the steel structure. If a transformer needs attention, it is pushed on the car and taken to the house for repairs. Beneath the transformers are oil pipe lines. These are so arranged that disconnecting is simple, and the oil in the transformers can be changed while they are on the line.

TRANSMISSION LINES

The main transmission line is 46 miles long, extending from the plant to Beckley. The line is sectionalized at four division points, where frames carrying switches are placed for cutting out the section in case of trouble with one circuit. A diagram of the line connections is shown in Fig. 20. The steel main line poles and square anchor towers carry crossarms for double power circuits and two ground wires. The power cables are of 000

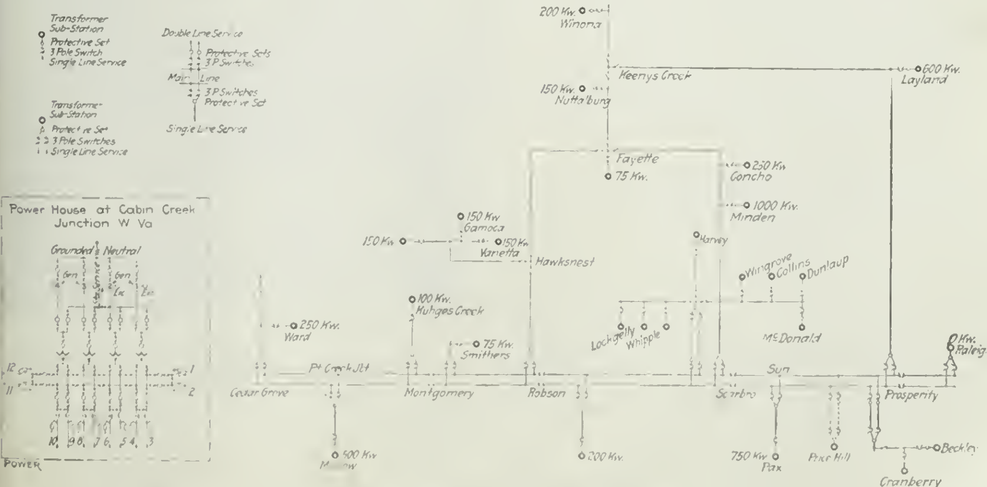


FIG. 20. DIAGRAM OF THE LINE SYSTEM

seven-strand copper wire. The $\frac{3}{8}$-in. ground cables are seven-strand galvanized wire. There are a large number of distribution branches led off from both main circuits by take-off frames.

Three-disk suspension insulators are used on the power circuits, with four disks used for strain.

The Virginian Power Co. also owns sites on the New River, all in the immediate vicinity of the bituminous coal fields of West Virginia and eastern Kentucky. The total power which it would be possible to develop from these sites is 170,000 kw., and if operated on 30 per cent. load factor, the assumed power which could be generated would be 450,000,000 kw.-hr.

PRINCIPAL EQUIPMENT OF THE VIRGINIAN POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbo-generators	Double flow.	10,300 kv a	Main units	1800 r.p.m . 185 lb. steam, 50 deg. superheat, 5-phase, 60 cycles, 6600 volts. ..	Westinghouse Co.'s
2	Exciters	Self contained	90 kw ...	With main turbo generators... ...	Direct coupled, 1800 r.p.m., 125 volts	Westinghouse Elec. & Mfg. Co.
1	Exciter	Direct current	100 kw.	Stand-by unit	1800 r.p m , 125 D C. volts .	Westinghouse Elec. & Mfg Co.
1	Turbine	Single stage	100 kw.	Drive stand-by exciter	2400 r.p.m., 185 lb steam, 50 deg. superheat	Westinghouse Mch. Co.
2	Condensers	Leblanc	No. 20..... .	With main turbine	28-29-in. vacuum . .	Westinghouse Mch. Co.
2	Turbines	Re-entry..	250 hp. . .	Driving condenser pumps..... .	185 lb steam 50 deg superheat, 700 r p.m.	Westinghouse Mch Co.
2	Pumps	Vertical cent.......	24 in., 17,000 gal. per min	Water to house flume	Motor driven, 385 r p.m.	I. P. Morris Co.
1	Pump	Vertical cent.	18 in., 8500 gal. per min.	Water to house flume	Turbine driven, 550 r.p.m.	I P. Morris Co.
2	Motors	Induction.........	320 hp . .	Driving vertical pumps	385 r p.m., 440 volts, 3-phase, 60 cycles. .	Westinghouse Elec. & Mfg. Co.
1	Turbine	Vertical.	165 hp. .	Drives vertical pump	550 r p.m., 180 lb. steam, 50 deg superheat	Terry Steam Turbine Co.
1	Pump..	Double suction, cent ..	6 in., 1200 gal. per min. ..	Transfer water to 50,000 gal. tank..	1760 r p.m , motor driven .	R. D Wood & Co.
1	Pump	Double suction, cent	6 in , 1200 gal per min....	Transfer water to 50,000 gal. tank....	1760 r p m., turbine driven . ..	R. D. Wood & Co.
1	Motor	Induction...	75 hp	Driving transfer pump	1760 r p m., 440 volt, 3-phase, 60-cycle..	Westinghouse Elec. & Mfg. Co.
1	Turbine	Single stage.	75 hp. . .	Driving transfer pump	1760 r.p.m., 185 r p.m., 50 deg. superheat	Westinghouse Mch. Co.
2	Heaters	Open, Cochrane .	10,000 hp.	Heating feed water	Using exhaust steam from auxiliaries	Harrison Safety Boiler Works
2	Pumps	Triplex	400 gal. per min. cap .	Boiler feeders. ...	3000 r.p.m., work against 200 lb. pressure..	Westinghouse Mch. Co.
2	Turbines.	Single stage ..	96 b hp . .	Driving boiler feed pumps	3000 r.p.m., 185 lb. steam, 50 deg superheat	Westinghouse Mch. Co.
12	Boilers	Rust, water tube	600 hp. each	Steam generators	185 lb. steam, 50 deg. superheat	Babcock & Wilcox Co.
12	Stokers.	Murphy, automatic	8x12 ft	Dutch oven furnaces	Engine driven, natural draft ..	Murphy Iron Works
2	Stacks.	Steel, lined..	11'4" inside dia , 262' high	One for each six boilers	Natural draft .	M. B. Pollock
1	Tower hoist.	Steel	150 tons coal per hr	Handling coal and ash	Motor drive	C. W. Hunt Co.
1	Transformer system.	Outdoor type..		For line service	6600 to 44,000 volts	Westinghouse Elec & Mfg. Co.

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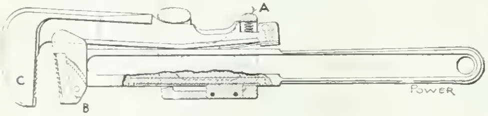
Harvey's Improved Wright Pipe Wrench

The wrench consists of but practically three working parts, the rocking jaw, the handle and the yoke that joins the two. The soft iron rivet, a weak point in the old wrench, has been eliminated, although the movable jaw has the same rocking motion necessary to the bite and release action of the wrench.

The illustration shows the design. The wrench is operated by holding it in one hand, pressing down with the thumb on *A* and at the same time pushing forward or pulling back the yoke. When adjusting the wrench, the jaws are opened wide and the point of the lower jaw *B* placed against the side of the pipe. Then the rocking jaw *C* is pulled with the thumb until its point touches the pipe, when the thumb is released and the jaws are dropped over the pipe.



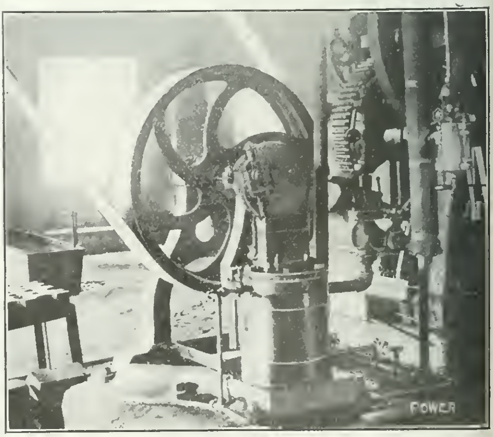
Improved Wright Pipe Wrench

This wrench is made by A. Harvey's Sons Manufacturing Co., Ltd., First and Woodbridge St., Detroit, Mich.

An Old Steam Engine

By D. O. Barrett

The accompanying illustration shows an old steam engine which is still in operation at Mansfield, Ohio. It is of the vertical type, and appears to be single-acting; this, however, is not the case. There are no crosshead and piston rod as is usual in the double-acting steam engine. Instead, the piston is extended out through one end of the cylinder, as shown. As this extension is hollow it allows sufficient space for the movement of the connecting-rod, one end of which is pivoted in the piston proper. This, of course, materially cuts down the effective area of one end of the piston. It is extremely hard to pack this end and prevent steam leakage from the cylinder.



Peculiar Design of Steam Engine

The engine is used for driving power hammers and punches in the forge shop. Its age is 35 years; perhaps more.

A 4000-Hp. Single-Stage Centrifugal Pump

By Dr. Alfred Gradenwitz

At the Funghera electricity works of the Società Alta Italia (near Turin), there has been in operation for a short time a centrifugal pump, Fig. 1, remarkable both for its efficiency and dimensions. The most important feature of this single-stage pump, constructed by Messrs. Sulzer Bros., of Winterthur, Switzerland, is that a single rotor is used to deal with a maximum barometric head of 498.6 ft. and a maximum output of 475.5 gal. per sec. at 1002 r.p.m.

This pump serves to accumulate water and is intended at given intervals to raise the contents of a suction tank into an elevated storage reservoir. The suction and discharge heads are bound to increase during pumping, as the suction tank is emptied and the storage reservoir filled, and these fluctuations must not entail any reduction in efficiency: the constructors, in utilizing the available energy to the best advantage, had to solve a difficult problem.

Fig. 2 illustrates the working conditions. The storage reservoir has a capacity of 11,000,000 gal. The guaranteed power consumption for the whole duty of the pump is 29,000 kw.-hr., corresponding to 0.0026 + kw.-hr. per gal. of raised water. On tests on delivery, however, this guaranteed figure was not reached. The geodetical head, at the beginning of pumping—i.e., with the lower tank filled and the upper tank emptied—is 440.5 ft. and at the end, 496. The head thus fluctuates each time about 55.8 ft. The output of the pump, at the beginning, when the head is a minimum, should be 475.5 gal. per sec., and while slightly decreasing as the head grows, should allow the whole amount of 11,000,000 gal. of water to be lifted in about 8½ hours.

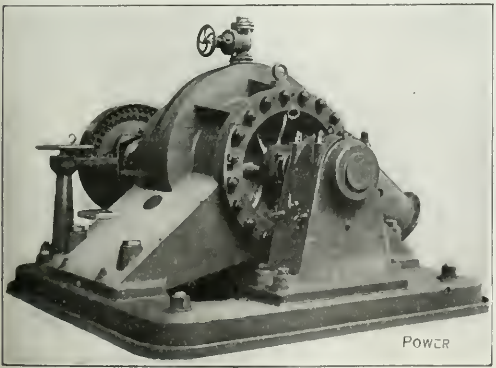


Fig. 1. Single-Stage Centrifugal Pump

Curve *A* illustrates the growing of the water level in the upper tank and curve *B* the falling of the level in the lower one. Both are approximately rectilinear, and the same applies accordingly to curve *C*, which represents the growing of the suction head. Curve *D* shows the amount of water raised per second at different times of working, and curves E_1 and E_2 show the behavior of the manometrical and geodetical heads. The difference between these heads, during the second half of the pumping operations, is considerably smaller than during the first. This is due to the pump, at the beginning, in dealing with the small geodetical head, having to be partly throttled by the regulating slide. After about 3½ hr. working of the pump, a condition is reached with a geodetical head of 485.4 ft., when there is no longer any need for throttling the regulating slide.

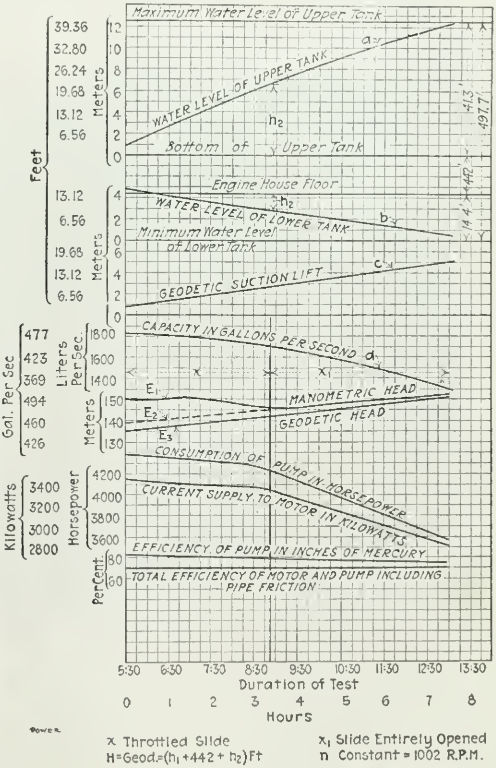


Fig. 2. Chart Showing Working Conditions

These curves show the pump to adapt itself in a high degree to various heads, lifting relatively small amounts of water at the beginning when working under a low head. While this adaptability could have been driven even slightly farther by chosing a somewhat larger motor-generator set, the immaterial improvement of efficiency thus attainable would not have warranted the extra cost. The dotted auxiliary curve E_3, which is based on the imaginary hypothesis that throttling by means of the regulating slide is not required, allows the amount of work expended in throttling, during the first stage of operation, to be gaged. When distributed over the whole time of working plus this would not even amount to 2 per cent. of the whole work.

The curves show the efficiency, as referred to the barometrical head, to rise to 81 per cent. during times of heavy loads on the pump in throttling. The extremely high total efficiency of 70 per cent. for the pump, inclusive of the motor and conduits—that is, the efficiency, as referred to the geodetical head—should be noticed. The straight course of the curves also shows the total efficiency to remain constant during the whole time the pump was in operation, which, during the throttling stage, was working under especially advantageous conditions, as may be seen.

* *

Reducing an Engine Test to Guarantee Conditions

By R. H. Corbett*

A Nordberg poppet-valve engine, sold to the United States Metals Refining Co. for its Grasselli plant, was guaranteed to produce a horsepower-hour on 10.9 lb. of steam under the conditions stated in the first column of the following table. On its acceptance test it required 11.015 lb., but the conditions were those shown in the second column:

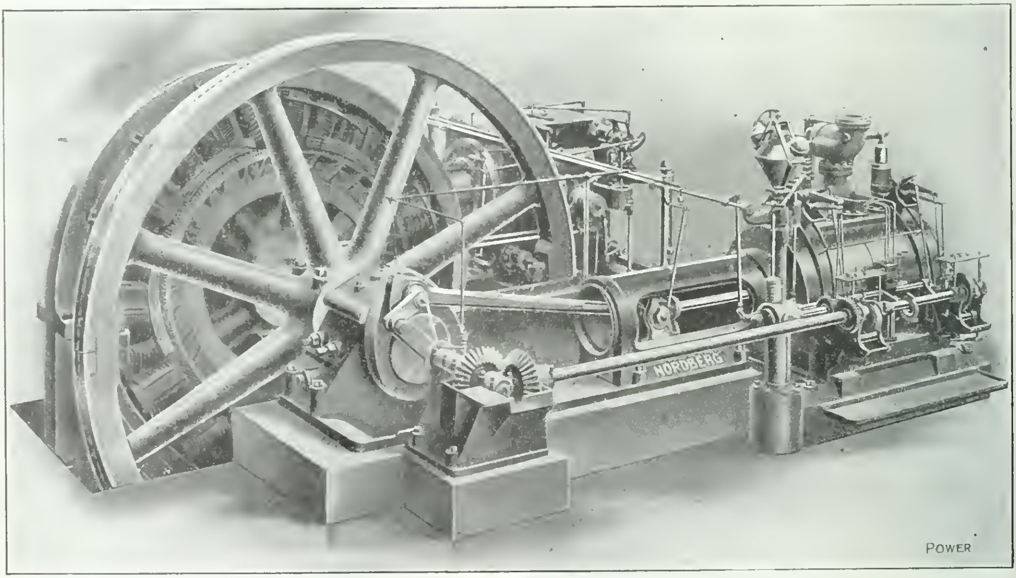


Fig. 1. Nordberg Cross-Compound at Grasselli Plant, U. S. Metals Refining Co.

	Guarantee	Performance
Initial pressure, lb. gage	150	154.78
Back pressure, in. mercury abs.	4	3.9
Superheat, deg. F.	100	76.15
Steam rate, lb. per i.hp.-hr.	10.9	11.015

In view of the lower superheat furnished it and the departure of the other conditions from those of the contract, did the engine meet its guarantee?

This was determined by comparing the Rankine efficiencies of an engine using 10.9 lb. of steam under the conditions of the contract and 11.015 under the conditions of the test.

The number of B.t.u. convertible by an engine of 100 per cent. efficiency working between given limits may be found by the following formula, the derivation of which appeared in Power of February 2, 1909, page 225:

$$U = H_1 - h_2 - (N_1 - n_2)T_2$$

U = Heat convertible by a 100-per cent. engine working in Rankine cycle in B.t.u.;

H_1 = Total heat per pound of steam in initial condition;

h_2 = Heat of the liquid, per pound in final condition;

N_1 = Entropy of steam in initial condition;

n_2 = Entropy of water in final condition;

T_2 = Absolute temperature of steam in final condition = Fahrenheit temperature t_2 due to back pressure + 459.64.

This gives the number of B.t.u. which a 100 per cent. engine could get out of a pound of steam. Multiply it by the number of pounds of steam used per horsepower-hour, and it gives the B.t.u. which a 100 per cent. engine could get out of the steam, which the engine uses. A horsepower-hour is equivalent to

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*Representative of the Nordberg Mfg. Co.

$$\frac{33{,}000 \times 60}{777.52} = 2546.56 \ B.t.u.$$

This is what the engine actually got out of a given amount of steam: the figure above derived is what a 100 per cent. engine would have got out of it. The former divided by the latter is the so called "Rankine" efficiency of the engine. This is worked out for the two cases below, the values being derived from the Marks-Davis tables of the physical properties of steam.

GUARANTEE CONDITIONS

150 lb. gage
14.4 barometer

164.4 lb. abs. initial pressure — 4 in. mercury abs. back pressure — 100 deg.zF. superheat

$1251.94 = H_1$
$93.38 = h_2$

$N_1 = 1.6273 \quad t_2 = 125.48$
$N_2 = 0.1738 \quad\quad\quad 459.64$

$1158.56 = H_1 - h_2$
$N_1 - N_2 = 1.4535 \times 585.12 = 850.47 = (N_1 - n_2)\ T_2$

$308.09 = H_1 - h_2 - (N_1 - n_2)\ T_2$
10.9

$3358.18)2546.56$

75.8 per cent

TEST CONDITIONS

154.78 gage
14.4 barometer

169.18 lb. abs. initial pressure — 3.9 in. mercury abs. back pressure — 76.15 deg. F. superheat

$1236.84 = H_1$
$92.45\ h_2$

$N_1 = 1.6075 \quad t_2 = 124.55$
$N_2 = 0.1722 \quad\quad\quad 459.64$

$1144.39 = H_1 - h_2$
$N_1 - n_2 = 1.4353 \times 584.19 = 838.49 = (N_1 - N_2)\ T_2$

$305.90 = H_1 - h_2 - (N_1 - n_2)\ T_2$
11.051

$3380.5\ )2546.56$

75.3 per cent.

It will be seen that the efficiency with which the engine performed under the test conditions is practically that with which it would have been required to perform under the test conditions to meet the guarantee, which was, therefore, considered as having been accomplished. The figures of the test are as follows:

DUTY TEST OF NORDBERG CROSS COMPOUND CONDENSING POPPET VALVE ENGINE

Made by Nordberg Manufacturing Co. and the United States Metals Refining Co., on engine located at the United States Metals Refining Co's. Grasselli Plant, to determine steam consumption per indicated horsepower.

Diameter—high pressure cylinder, in.	19
Diameter—low pressure cylinder, in.	44
Stroke, both cylinders, ft	3.5

Date of test—October 1st, 1913

Total Quantities, Time, Etc

Duration of test, hr	10
Water fed to boilers during test, lb	72,307
Loss of steam from boilers and pump leakage during test, lb.	3928
Total water charged to engine, lb.	68,379
Water charged to engine, per hr., lb.	6837.9

Pressures

Steam at throttle, lb. per sq in.	154.78
Barometer, 29.316", lb. per sq.in	14.4
Absolute steam pressure, lb. per sq in	169.18
Absolute back pressure, lb. per sq in	1.91
Receiver pressure, lb. per sq in	6.35
Pressure in low pressure jacket, lb. per sq in	25.0

Temperatures, Deg. F

Steam at throttle, deg. F	444.21
Corresponding superheat at throttle, deg. F	76.15
High pressure exhaust, deg. F	232.1
Low pressure inlet, deg. F	239.52
Corresponding superheat, deg. F	7.42
Feed water, deg. F	104.4
Air in engine room, deg. F	84.8
Steam at boilers, deg. F	490.28
Corresponding superheat at boiler, deg. F	122.78

Electrical Readings

Ammeter on switch board	4639.76
Voltmeter on switch board	86.03
Kilowatts, corresponding	399.17
Horsepower corresponding	535.07

Speed

Average revolutions per min.	100.34
Piston speed, ft. per min.	702.38

Power Developed

High-pressure cylinder, i.hp.	312.46
Low-pressure cylinder, i.hp.	308.38
Total power developed	620.84
M.E.P. in high-pressure cylinder	52.605
M.E.P. in low-pressure cylinder	9.557
M.E.P. in high-pressure cylinder referred to low-pressure	9.511
Total M.E.P. referred to low pressure cylinder	19.068

Efficiency Results

Steam per indicated hp. per hr., lb	11.015

A photograph of the engine is reproduced in Fig. 1. The heads, but not the barrels of both the high- and low-pressure cylinders, are steam jacketed. Poppet valves are used on the high-pressure cylinder, as shown in Fig. 2, but the low-pressure is fitted with Corliss valves, with separate eccentrics for the steam and exhaust. The engine has thus the advantage of valves with no frictional contact for use in the superheat and of the Corliss valve with its lesser clearance when the temperature has got below that at which there is likely to be any difficulty in lubrication. The valve gear on the low-pressure cylinder is of the Nordberg full-stroke type, permitting cutoff to occur at any point up to completion of the stroke. The Nordberg Co. was organized for the purpose of making a cutoff governor for slide-valve engines. The valve used in the governor was of the poppet or double-beat type operated by a separate eccentric and tripped by fly balls at each stroke, thereby converting the engine to which it was attached to an automatic engine. The governor was a success from the beginning and the step to the building of the poppet valve engine was a natural one.

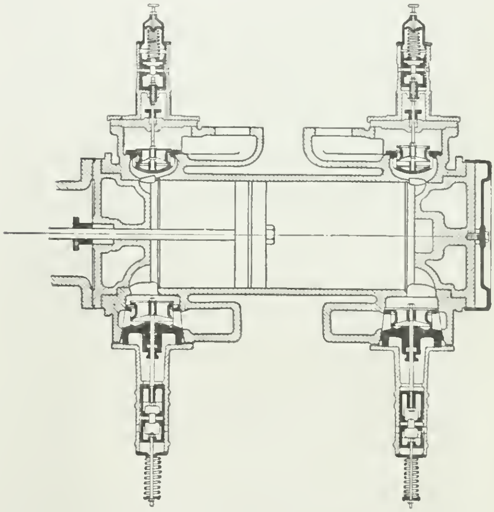

Fig. 2. Cross-Section of High-Pressure Cylinder

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Mountains of Culm Disappearing—The mountains of culm which break the sky line throughout the anthracite coal region of Pennsylvania and which were for many years considered a nuisance are now being made to serve a useful purpose. There is at present a market for almost any grade of anthracite that will burn, and no more coal goes to the culm bank except for temporary storage and subsequent recovery by washers. These ranges of artificial hills, unsightly monuments to former waste, are contributing their share to the total coal production and are rapidly disappearing. Even the waste from the culm-bank washers is being utilized, for it is flushed into the mines and partly fills old workings where it cements together and furnishes support to the roof when the coal previously left for pillars is removed.

Ash Influence on Fuel Value of Small Anthracite Coal

By Frank G. Philo

The value of coal as fuel depends not alone upon the total number of heat units, or B.t.u. per pound, but upon the fraction of the total heat contained which can be produced under actual conditions of combustion and operation. The B.t.u. value of one coal as represented by a calorimetric determination may be higher than a second actually, but the lower B.t.u. coal often shows a higher actual fuel value. This can be seen when it is considered that the calorimetric determination does not include the moisture in the coal, as fired, the amount and composition of the ash, whether it contains excessive slag or clinker-forming constituents, or there are present such impurities as sulphur compounds, which in spite of their heat-producing properties are often the cause of partial corrosion of the boiler, the breeching and the bunkers.

The sample of coal tested by the calorimeter is usually burned in an atmosphere of pure oxygen, a condition much different from that in practice, where an atmosphere of only 21 per cent. of oxygen exists. It follows that the most practical way to determine the relative fuel value of different coals is to burn a considerable amount of each grade upon the grates and in the furnace under operating conditions and note the characteristics accompanying each grade.

Tables 1 and 2 and the charts, Figs. 1 and 2, show the results of tests during which over 20,000 tons of No. 3 buckwheat coal were fired and over 500 chemical analyses were made.

The coal used was fired into the same type of furnace and upon the same "sawdust" grate, having small circular air spaces ranging from $\frac{3}{32}$ to $\frac{1}{8}$ in. in diameter. The area of the air spaces represented about 8 per cent. of the total grate area. Forced draft was used, and an average pressure of 1 in. of water. As practically no coal fell through the small openings, the fuel losses in the ashpits represented these, due to the combustible carried with the ash at cleaning periods, which, in this plant, occur once every six hours. It was found practically impossible to economically burn out more combustible after it had been burned until it represented about 18 per cent. of the material left on the grates after "pushing back." This fixed ratio of combustible to refuse mainly accounts for the rapid rate in which the losses in the ashpits increased with the higher ash coals. The percentage of the total combustible lost was calculated from the following formula:

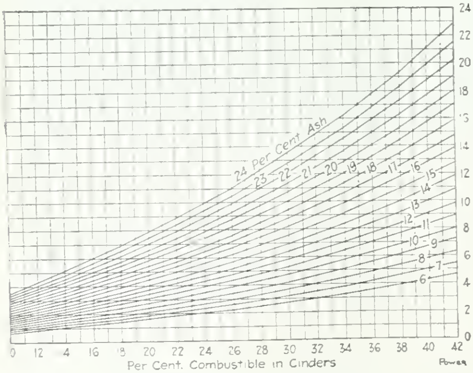


Fig. 1. Curves Which Designate Ashpit Losses

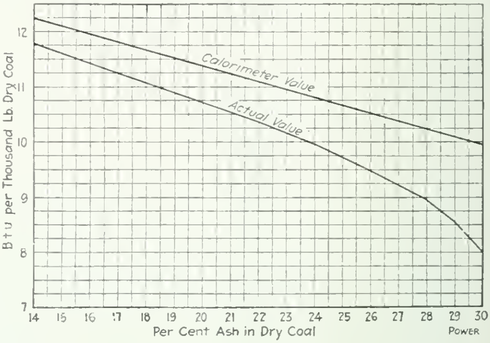


Fig. 2. Curves Showing Actual and Calorimeter Value of Fuel

$$\textit{per cent. total combustible lost} = \frac{(\textit{per cent. ash in dry coal}) \times (\textit{per cent. comb. in dry refuse})}{(100 - \textit{per cent. ash in dry coal}) - (100 - \textit{per cent. combustible in dry refuse})}$$

With anthracite as fuel, the value of the combustible in the refuse is almost the same as that of an equal weight in the coal fired, so no correction was applied. To simplify the calculation of ashpit losses the curves in Fig. 1 were plotted, based on the formula given.

TABLE I. COMPARISON OF THE CALORIMETER VALUE AND ACTUAL VALUE* OF DIFFERENT ASH COALS

Per Cent. Ash in Dry Coal	Calorimeter Value per Lb. Dry Coal B.t.u.	Actual Value per Lb. Dry Coal B.t.u.	Act. Value / Cal. Value Per Cent.
14	12,220	11,755	96.2
16	11,920	11,420	95.8
18	11,640	11,080	95.2
20	11,350	10,714	94.4
22	11,080	10,348	93.4
24	10,800	9,936	92.0
26	10,510	9,459	90.0
28	10,240	8,949	87.4
30	9,950	8,000	80.4

*The "actual value" of a pound of coal is here taken to mean the difference between the total B.t.u. contained in 1 lb. of dry coal fired and the B.t.u. in the combustible in the dry refuse per pound of dry coal fired.

TABLE II. CALORIMETER AND ACTUAL VALUES OF DIFFERENT ASH COALS AS COMPARED WITH 14 PER CENT. ASH COAL AS A STANDARD

	Calorimeter Value	Actual Value
Per Cent. Ash	Cal. Val. of 14% Ash Coal Per Cent.	Act. Val. of 14% Ash Coal Per Cent.
14	100.0	100.0
16	97.5	96.9
18	95.3	94.1
20	92.9	91.0
22	90.7	88.3
24	88.4	84.5
26	86.0	80.5
28	83.8	76.1
30	81.4	68.1

The tables and curves will be found useful in calculating the penalties to be imposed for high ash when coal is to be purchased on specification. Although the actual values given will not apply to all sizes and kinds of coal, the actual-loss curve will be about the same. Of course, in computing the economic value of the different coals, due allowance must be made for the transportation costs, cost of handling the coal and refuse, and the increased depreciation and maintenance charges against the grates and stokers that accompany high ash and clinker. The reduction of the capacity of the boiler and the furnace must also be borne in mind, especially in plants where the boilers are required to operate at high overloads.

⁂

CO_2 as an Indicator of Boiler Efficiency

By M. K. Bryan

SYNOPSIS—Deals with the transfer of heat into boilers as indicated by the CO_2 content in the flue gases.

⁂

The efficiency of the furnace and grate is the ratio of the heat available for absorption by the boiler to the heat in the coal fired, and the efficiency of the boiler is the ratio of the heat absorbed by the boiler water to the heat available for absorption. Boiler efficiency, as usually expressed, combines these two and is that percentage of the heat of the coal fired which is absorbed by the water in the boiler. This is stated algebraically as follows:

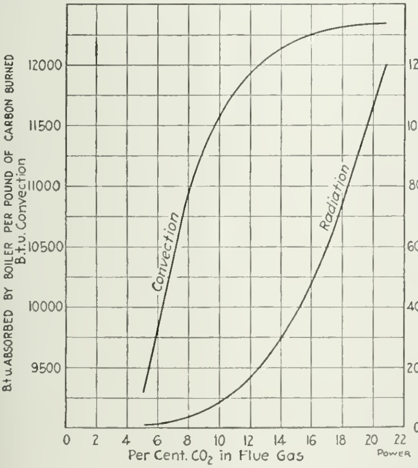


Fig. 1.

$$E = \frac{w\,(H - h)}{W H_1}$$

where

E = Boiler and grate efficiency;
w = Pounds of water evaporated in a unit of time;
W = Pounds of coal fired in a unit of time;
$H - h$ = Heat absorbed by one pound of water;
H_1 = The heat in one pound of coal as fired.

The above expression shows that E for a given installation depends upon the ratio $\frac{w}{W}$, and to increase the efficiency, more water per pound of coal must be evaporated.

This can be done by increasing the efficiency of the furnace and grate or by increasing the efficiency of the boiler. Increasing the tightness of the setting or the cleanliness of the heating surface, or perhaps changing the arrangement and properties of the gas passage, will increase the efficiency of the boiler, the efficiency of the furnace and grate not changing appreciably, but increasing the furnace and grate efficiency necessarily increases the efficiency of the boiler.

Increasing the furnace and grate efficiency without changing their design is, primarily, a question of air supply, generally, a reduction of air supply. The quantity of air supplied is indicated by the percentage of CO_2 in the gases of combustion, and the character of these gases, which is indicated by the percentage of CO_2, largely determines the combined efficiency of the unit because of the laws governing the transfer of heat from the products of combustion to the water in the boiler and because it depends upon the sort of combustion taking place.

The modes of heat transfer to the water in the boiler are by radiation from the fire and by convection from the gases to the outside of the water-heating surface, then by conduction to the inside of the heating surface—that is, through the metal and then by conduction from the inside of the heating surface to the water.

Radiation of heat from the furnace to the heating surface depends directly upon the difference of the fourth powers of the temperature of the furnace and that of the outside of the heating surface. It is expressed by the formula

$$H = K\,(T^4 - t^4)$$

in which H is the heat radiated from the furnace, whose temperature is T, to the outside of the heating surface having the temperature t; K is a constant dependent upon the relative positions of the radiating surfaces and the heating surfaces, and the units in which H is expressed. Fig. 1 has a radiation curve showing the heat radiated from a furnace to the heating surface plotted against CO_2 percentages. Note the increase in CO_2 following the increase in furnace temperature; see Fig. 2. The transfer of heat by convection from the gases to the heating surface depends directly upon the difference in temperature of the gasses and the heating surface and upon the weight of gas passing over the surface and indirectly upon the area of the gas passage. The amount of heat so transferred is stated by the formula

$$H = \frac{KW\,(T - t)}{A}$$

in which H is the heat transferred to one square foot of heating surface by a pound of gas and $(T - t)$ is the temperature difference of the gases and the heating surface, k being a constant.

The further transfer of this heat by conduction through the heating surface depends directly upon the temperature difference of the two sides of the metal and upon the composition of the metal, and indirectly upon its thickness. The transfer of heat from the inside of the heating surface to the water is dependent upon the rapidity of circulation, the character of the surface and the difference in temperature of the surface and the water.

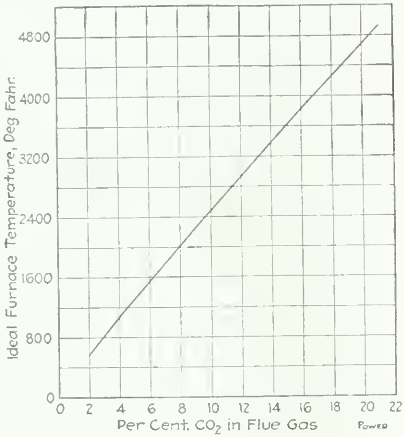


Fig. 2.

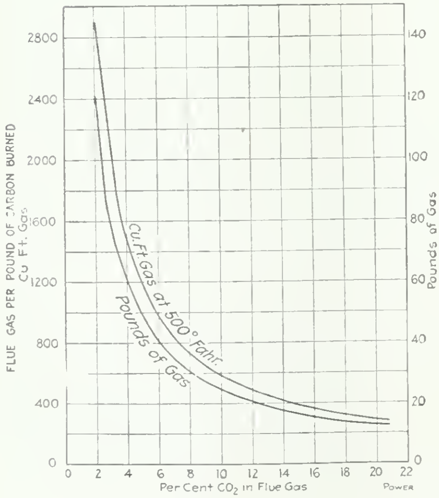


Fig. 3.

The transfer of heat through the boiler to the water is dependent, then, upon the design of the boiler, and the modern boiler is of such design that only a comparatively small difference in temperature is necessary here to take care of the heat transferred, even when the boiler is being operated at several times its rated capacity.

The curve marked convection in Fig. 1 shows the increase in heat so transferred as the CO_2 percentage increase, and this is due to increased furnace temperature. Fig. 3 shows curves of volume and weight of the gases plotted against CO_2 percentages. It will be remembered that the weight of the gases is a factor in the convection of heat; this accounts for the shape of the convection curve.

In constructing the curves, Figs. 2 and 3, a fuel of pure carbon was considered as completely burned to CO_2, the varying percentages of CO_2 being due to different excesses of air supplied. The temperature plotted is the ideal of maximum temperature attainable. A pound of carbon requires 11.6 lb. of air to supply the oxygen for burning it, and the products of combustion weigh 12.6 lb., as shown in Fig. 3. These gases absorb the heat of combustion, or 14,500 B.t.u., and their temperature is increased from that of the metered air, 70 deg. to 4800 deg. F. However, if an excess of air is admitted and the CO_2 percentage is 6 instead of 20.8, the gases of combustion will weigh 41 lb. These gases now absorb 14,500 B.t.u., and the final temperature is lower because of the increased weight of gas to be heated.

It is clearly seen, then, that a good CO_2 percentage means a good furnace gas temperature, and consequently a more rapid transfer of heat to the boiler than with lower CO_2 percentage. This means better boiler efficiency.

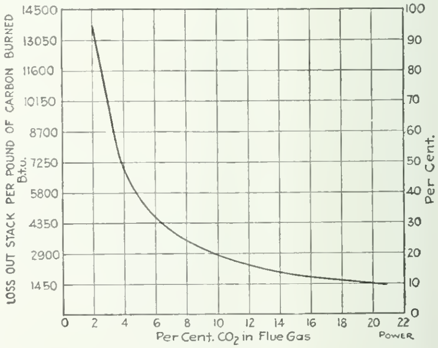


Fig. 4

The greatest loss of heat, and consequently efficiency, is the heat carried away in the escaping gases. Fig. 4 shows a curve of the heat carried away in stack gases at 550 deg. F. plotted against CO_2 percentages. The heat is expressed in B.t.u. and as a percentage of the heat in the fuel. The factors entering into this loss are stack temperature and the weight of gas per pound of fuel. Each pound of gas leaving the boiler requires 0.24 B.t.u. to raise its temperature one degree—i.e., its specific heat is 0.24. If the air entering the furnace has a temperature of 80 deg., and the gases leaving the boiler have 550 deg., they will carry out 113 B.t.u. per pound, this being the quantity of heat taken up from the coal in raising their temperature to 550 deg. If the escaping gases have a temperature of 80 deg. the heat of the coal carried away is zero. It is, however, impossible to obtain a stack temperature less than that of the water in the boiler, which at 150 lb. gage pressure is 366 deg.

Under this condition there is a necessary loss of 68.5 B.t.u. per pound of gas, which amounts to 865 B.t.u., or 6 per cent. of the heat of the coal with the minimum of gas and 20.8 per cent. CO_2. However, the cost of the additional heating surface to attain this low figure is prohibitive and the loss must be kept to a minimum by reducing the products of combustion—i.e., increasing the CO_2. With a stack temperature of 550 deg., Fig. 4, shows a minimum loss of 10 per cent. with 20.8 per cent. CO_2. With 10 per cent. CO_2 in the stack gases, 25 lb. of gas per pound of fuel, the loss is 19.5 per cent., while with 6 per cent. CO_2 in the stack gases, 41 lb. of gas per pound of fuel; the loss is 32 per cent. or an increase of 64 per cent. caused by increasing the weight of the gases 64 per cent.

These considerations of the laws of heat transfer and combustion show that good CO_2 in the flue gases is an indication of proper overall efficiency, other things being equal, for with good CO_2 in the flue gases there will be good CO_2 in the furnace. Consequently, a good furnace temperature conducive to the efficient transfer of heat from the gases to the water in the boiler will result in a low stack temperature, and, further, there will be a small excess of air, meaning a less weight of gas out of the stack, which with the low stack temperature means a small loss.

High CO_2 percentages may be accompanied by considerable CO and the consequent loss, but, this condition is one of imperfect combustion, the result of faulty firing methods or improper furnace design for the requirements and does not argue against the value of CO_2 as an indicator of efficiency.

* *

Influence of the Ignition Arch

By Joseph Harrington

SYNOPSIS—A discussion of the importance of early and rapid ignition in chain-grate stokers and the effects of a suitably designed ignition arch.

*

The influence of the ignition on the results of burning coal on a chain grate has not yet been fully appreciated even by those directly concerned with such matters.

In the issue of Power for Dec. 10, 1912, the writer set forth the principles governing the design of the ignition arch in its relation to the furnace in general, but more particularly to the fuel bed. Briefly, this showed how the ignition arch reflects heat from the rear or highly heated portion of both fuel bed and furnace brickwork to the front where the fresh coal enters.

An arch of this design is substantially a heat mirror. The correctness of the theory on which it is based has been so repeatedly demonstrated that this theory must now be accepted as definitely proved.

In the chain-grate type of automatic stoker the various steps in the progressive combustion of coal are perhaps more orderly and undisturbed than in any other, and the results of a proper completion of each of the various stages of combustion can be more readily and clearly followed. As in most mechanical processes as well as in the personal efforts of the individual, the old saying, "Well begun is half done," applies with particular force to the series of events occurring in the furnace. It must be clearly borne in mind that the complete combustion of coal involves an orderly series of events, which can be briefly outlined as follows:

The fresh fuel, containing some moisture, enters the furnace where it is subjected to the influence of the furnace temperature. The moisture is first driven off, which in any given particle of coal probably takes but a very short time. This is accomplished by the time the temperature of the particle of coal under consideration reaches the temperature of 212 deg. F., and as the temperature continues to increase, the volatile constituents begin to come off. If the temperature at the point of ignition is sufficient, these burn in the space above, and approximately as fast as they are distilled. The burning of this portion of the fuel forms one source of the heat required for the ignition of the succeeding charge or unit of fresh coal.

The volatile contents are not all driven off at the same temperature, so this portion of the process continues during an appreciable time or until the fuel has traveled some distance in the furnace.

Temperature readings taken at the point of ignition indicate that about 1100 deg. must be obtained before the volatile will properly ignite and 1300 deg. must be had if the ignition is to be prompt and bright.

About the time that the volatile is all gone the particle of coal has reached a quite high temperature and the fixed carbon begins to burn. That it requires considerable time to complete the combustion of the fixed carbon probably makes this step about the most noticeable and easily distinguished event in the entire combustion process. A higher temperature is required than for the volatile and on account of the solid nature of the fuel (which permits of its burning only on the surface), the proper completion of the combustion of the fixed carbon becomes one of great importance and some difficulty.

It is obvious that this particular stage must be begun as early as possible, in order that the end may be within the time limit of the chain-grate travel. A prolific source of inefficiency is the dumping of unburned fuel into the pit, and analysis shows that this is almost entirely fixed carbon.

Early and rapid ignition, therefore, becomes, as a consequence, vitally necessary to the proper completion of the entire process. I would divide the advantages to be gained into two main divisions:

1. The complete burning of the volatile contents at or near the front of the furnace results in smokeless combustion.

2. The early completion of the fixed carbon combustion reduces or eliminates the loss of fuel to the ashpit.

Smokeless combustion is unquestionably one of the most important and active subjects of discussion by engineers that at present occupies both the technical and nontechnical world. Many strange devices for "burning the smoke" have been devised and unusual and expensive furnace designs have been built to accomplish the same purpose. As often happens in such cases, the principal cause of smoke-laden gases has been overlooked. Smokelessness consists not so much in burning or eliminating smoke as it does in securing combustion that does not result in the production of smoke at all. When it is remembered that the gases arising from the fuel bed are in the furnace but a few seconds, it will be appreciated that every foot of flame travel must be made as effective as possible. Any delay in starting the combustion process seriously affects the ability to complete it before the gases leave the furnace.

The proper place to begin the work is at the instant when the gases leave the fuel in which they are bound up, and the brightest and most intense ignition is none too bright or too intense for this purpose.

Any ignition arch, therefore, that accomplishes this result becomes one of the most potent factors in the elimination of smoke. The reflecting arch, as has been referred to, actually accomplishes just these results.

Any combustible matter which may pass into the ashpit is a direct and visible loss, and no arguments are needed to make this matter clear. As previously stated, however, the fixed carbon content of coal burns out more slowly than the volatile, and in the usual chain-grate setting a portion of it will pass into the pit unless its combustion is properly started and actively assisted.

This necessary assistance may be given by sustaining the temperature at the back of the furnace, so that the last portions of coke heavily mixed with ash may entirely burn out. There is no question but that the built-up bridge-wall is of great assistance under these circumstances. Indeed, some designers have gone so far as to build forward at this point, making a definite overhang.

From the standpoint of ignition, it is sufficient to obtain an expanse of incandescent brickwork at the rear of the furnace. The radiated heat from this wall is of definite value for ignition purposes and can best be utilized by the deflection arch. The design of this arch must be made with this in mind, that the face of the bridge-wall is, for ignition purposes, a source of heat similar to the fuel bed itself. The inclination of the arch must be determined with a view to catching this radiation.

Inasmuch as the termination of all of the events of the furnaces is directly dependent upon the beginning, any factor which contributes beneficially to the quality of that beginning becomes of prime importance. Furnace design has, heretofore, been seriously neglected with respect to ignition conditions and, apparently, we have been content with getting along as best we could with the ignition effect taking place several inches from the point of entrance. Or, if the ignition did reach the gate, we were content so long as any fire showed itself at all. Only under conditions producing a bright white flame just at the gate, should things be considered as in satisfactory shape. These conditions yield a wonderful stimulus to economical combustion and it is unlikely that intensity of ignition can ever be overdone.

⁂

Motors, Their Principles and Uses—I

By Gordon Fox

SYNOPSIS—This installment of the series takes up the relations between magnetic and electric circuits as bearing upon the fundamental operation of the electric motor.

⁂

The operation of all electric motors is based fundamentally upon the relations existing between magnetic and electric circuits. Magnetism can be considered as lines of force which follow a closed path through iron from south pole to north pole and through air from the north pole to the south pole. Magnetic materials possess low resistance to the passage of magnetic lines of force whereas non-magnetic materials possess high resistance. There is no total insulator of magnetism. The lines concentrate in a magnetic material, such as iron and spread in air. Fig. 1 shows how magnetic lines are distributed in the space between the poles of a magnet.

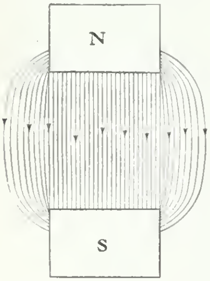


Fig. 1. Showing Magnetic Lines between Poles of Magnet

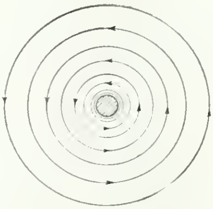


Fig. 2. Magnetic Lines Surrounding Conductors

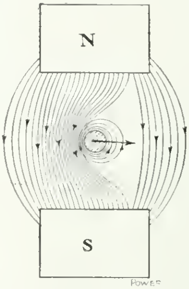


Fig. 3. Action of Magnetic Lines on Conductor Carrying Current

It was discovered by Faraday that a conductor through which an electric current is flowing is surrounded by a closed circuit of magnetic lines of force as shown in Fig. 2. It is evident that if a wire, carrying an electric current be placed in a magnetic field between two magnet poles the composite field resulting will be as shown in Fig. 3, the direction of the lines around the conductor depending on the direction of the current within it. The component lines of force are cumulative on one side of the wire and opposing on the other. Magnetic lines tend to seek the shortest path, hence those to the left of the wire tend to straighten out, acting similarly to elastic rubber bands and in doing so exert a sidewise force on the wire as indicated.

All electric motors are fundamentally dependent upon this principle for their action. They consist of electromagnetic fields mechanically arranged, usually upon an outer stationary part, acting upon conductors carrying current and placed upon the circumference of a drum which is free to rotate. The forces acting upon the conductors as above explained set the drum into rotation. There is a slight clearance or air gap between the stationary and rotating parts. The magnetism passes from a north pole of the field across this air gap, through the iron drum and across the gap again into a south pole, thence through the iron frame to the north pole again. The magnetism is maintained in the fields through the action of electromagnetic coils as explained later. Fig. 4 illustrates the principle of a simple motor.

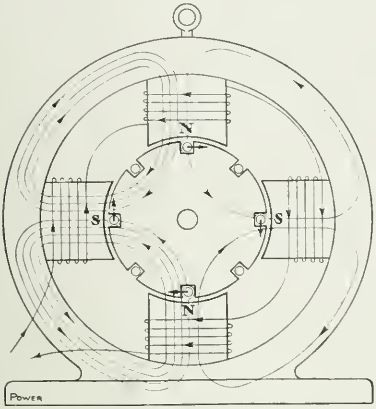


FIG. 4. ILLUSTRATING THE PRINCIPLE OF A SIMPLE MOTOR

The value of the force exerted upon a conductor carrying current in a magnetic field is proportional to two items; the strength of the magnetic field and the amount of current in the conductor. This leads to the basic law in all electric motors that mechanical force or torque is proportional to magnetic flux times the electric current.

It can be further shown that if a conductor forming part of a closed electric circuit be moved across a magnetic field the lines of force, acting again like rubber bands, stretch and assume a distorted condition similar to Fig. 3. This distorted condition as was previously shown can be considered as the resultant of two distinct magnetic fields. One of these fields is a closed circuit about the wire and can only be formed in the presence of an electric current in the wire. It follows that there is actually set up in the wire an electric current due to the presence of the magnetic field about it. This may be made more clear if it is considered that the wire is moved across the field to the point where the elastic lines of force break near the poles and wrap themselves about the wire. The wire is then surrounded by magnetic lines of force which is the condition of a wire through which a current is passing. The current is in fact found to pass through the wire to satisfy the condition. The fundamental principle of the electric generator follows: When a conductor forming part of a closed circuit is passed across a magnetic field an electric current is set up in the conductor.

It is further found that when a wire is placed in a magnetic field of varying strength, that is, a field in which the intensity or direction of the magnetism is made to change, an electric current is set up in the wire, which tends to oppose this change. The greater the rate of change, the greater the current produced in the wire. Upon this principle the electric transformer is based.

Summing up the fundamental principles; then

1. A conductor carrying an electric current in a magnetic field is subjected to a mechanical force at right angles to the wire and the field and proportional to the strength of the field and the value of the current.

2. A conductor of a closed circuit, moved across a magnetic field so as to cut the lines of force has set up in it an electric current the value of which is proportional to the strength of the magnetic field and the rate of cutting the magnetic lines.

3. A closed conductor placed in a magnetic field of varying strength has induced in it an electric current the value of which is proportional to the rate of change of the magnetism.

Returning to the principle that there is set up a magnetic field round a current-carrying conductor, the principle of the electromagnet is at once evident. A number of turns of wire are placed about an iron core which will not retain permanent magnetism to any considerable extent. When a current is passed through the wire the magnetic fields of the individual turns act collectively to cause the major portion of the lines of force to pass through the central iron core and through whatever magnetic circuit may offer the least resistance to the passage of the magnetic lines. Fig. 5 illustrates how the magnetic effects of the individual turns combine to form a strong resultant magnetism in the core. By changing the value of the electric current the strength of the magnetism is controlled. It is found that up to a certain point the strength of the magnetism, measured by the number of lines of force in a given area, varies almost directly with the strength of the magnetizing current. Above this point a greater increase of current is required

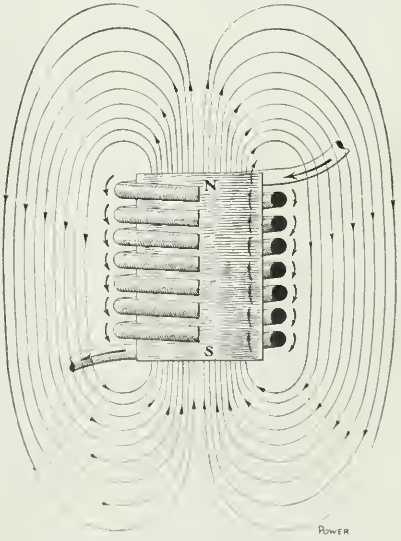


FIG. 5. MAGNETIC LINES OF INDIVIDUAL TURNS COMBINING TO FORM STRONG FIELD

to cause an equal increase in magnetic density. This point is called the point of saturation and when the iron is magnetized above this point it is said to be saturated. Fig. 6 illustrates the saturation curves of iron, steel and air.

It is evident that when a conductor is moved past a north pole of a magnet it will have generated in it current in one direction and when moved past a south pole the current will be set up in the opposite direction, since the magnetic lines are reversed. Any electric generator consists of a mechanical arrangement by means of which electric conductors are made to move past alternately north and south poles. As the electric pressure or voltage generated in a single conductor is small, coils are made up of many conductors with their ends connected to form a continuous circuit. The connections are so arranged that the voltages in the wires under north and south poles all act cumulatively. Referring to coil *A*, Fig. 7, in the conductors under the north poles the current will flow down through the plane of the paper, away from the reader, and in those under the south poles, it will flow toward the reader. When the conductors have moved through one pole space (in this case 180 deg.) this direction will be reversed. Since the conductors are in series the currents in coil *A* will all be in the same direction.

In an alternating current generator the ends of these circuits form the terminals of the machine and the current which passes through the wires first in one direction and then in the other direction is called an alternating current.

At the instant the conductors pass the center of the poles the rate of cutting magnetic lines is greatest and the instantaneous voltage generated is a maximum. When they pass a point midway between the poles the voltage is zero. Fig. 7 illustrates how the magnetism is distributed under the poles of a generator and how the instantaneous voltages change. The voltage may be considered as starting at zero, reaching a maximum in a given direction, falling again to zero, reaching a maximum in the opposite direction and falling again to zero. This series of changes occuring when a conductor passes two poles or 360 magnetic degrees is called a cycle. The frequency is the number of cycles per second, 25, 60 and 133 being the common commercial frequencies.

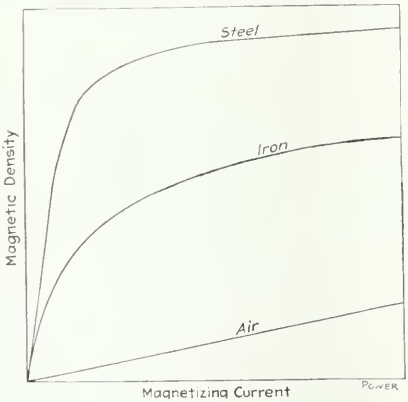
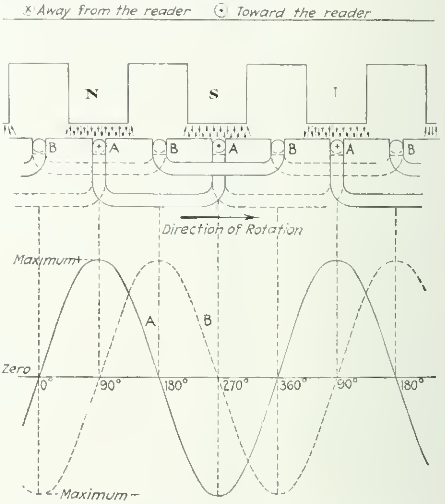


Fig. 6. Saturation Curves for Air, Iron and Steel

Consider that when the first set of conductors is midway between poles, a second set of conductors is directly under the poles. At the instant the voltage in coil *A* is zero the voltage in conductors *BB* is a maximum. Such an arrangement occurs in a two-phase generator and the voltages are said to be displaced 90 degrees or "quarter phase." Similarly three sets of conductors equally spaced have generated in them voltages 120 electrical degrees apart; a generator with its coils so arranged being called a three-phase machine.

It is possible to bring the ends of the conductors on the rotating element of a generator or motor to a current collecting device called a commutator which is made up of a number of copper segments separated by mica strips. If the brushes are placed at proper intervals, rubbing against this commutator, the current which is collected and passes through the external circuit connected to the brushes, is unidirectional and does not fluctuate in value as does an alternating current. This will be evident if it is noted that, the poles and brushes being fixed, their relative position is constant. The coils which deliver current to the brushes at any instant are therefore always in the same relative location with respect to the poles. It follows that the direction of the voltage in the coils connected through the commutator to the brushes is always the same. Stated in another way: The voltage generated within the conductors is actually alternating in value but the conductors deliver current to one set of brushes when passing under north poles and to the other set when passing under south poles. It will be seen then that these brushes, which lead to the terminals of the machine, are always of the same relative polarity hence in an external circuit between them the current will always flow in the same direction. This class of electric current is called direct current and a generator arranged to deliver it is called a direct-current generator.



Note The relations between the upper and lower diagrams are correct only for one position as shown. To comprehend other positions the poles may be considered as moving opposite to the direction of rotation as shown

Power

Fig. 7. Electrical Relations in Two-Phase Winding

Editorials

The Operating Engineer as a Purchasing Agent

"Well bought is half sold," is an old and true saying. Well bought means getting the thing which will produce the best results with the least money. A few years ago buying meant jockeying, bargaining, beating around the bush, with the idea that the buyer was entitled to no mercy if the seller could "put anything over on him." Today that is all very different. There are sporadic cases of downright dishonesty in selling, but they are so few, and it is so possible usually to correct them between the time of delivery of the goods and the paying of the bill that they may almost be considered a thing of the past. There does, however, remain a large opportunity for judgment on the part of the buyer and for good advice on the part of the salesman.

Every really good house is trying to send out men to sell its product that are really engineers, and who realize that their own personal interest as well as that of the firm lies in selling the thing which will best serve the purchaser. Not every firm has yet succeeded in getting all of this type of salesman that it needs, however. Until such a time, and for a long time after, the buyer will have to experiment to some extent, on his own account and discover for himself the peculiarities of his plant which demand treatment different from that of some neighboring one. Because a 500-hp. plant on one side of the street finds that Sam Jones' Triple JBX packing, or oil, or gage glasses give the best results under the care of Mike Jacobson is no sign that *you* cannot find a better packing to use, or a better coal to burn, or a longer lived gage glass, for your plant even though you have the same horsepower of boilers as the other.

A general purchasing agent is more than apt to be influenced by the fact, or the alleged fact that some large plant uses these brands, than he is by your unsupported statement that you have found something else better. The salesman comes in with a clean collar and nice looking shoes and you come in minus a collar and with shoes that you can work in. Your rig ought to appeal to the purchasing agent more than that of the salesman but it does not, and you cannot get to the manager to tell him about it, which is worse luck because the chances are he would understand you better than the agent does.

About the only recourse that is left you is in the way of records. If you can show that the X Y Z brand of cylinder oil carries you over 20 per cent. longer time than the A B C brand and you can show some nice looking cylinders he will probably never ask to take a look at hem. If you can check up your pounds of coal against kilowatt-hours, you have a pretty far reaching argument. Of course, you may have to first get a watt meter, which s not always easy, but if you cannot get that your water meter ought to be somewhat better than no guide at all, even if all the other water for the plant comes through it. You can get records that may make the boss anxious to give you the proper instruments to really keep track of what you are doing.

You buy coal for the sake of what it will do under your boilers, not someone elses. There are two factors in what it will do. one is the coal and the other is you, or what you can get your fireman to do. The combined result is what the owner cares about. You cannot get credit for your part unless the coal does its part. So far there appear to be no scientific tests for coal that measure up to actual use. They give indications but that is about all. The test should be one that will take into account the temperament, or the more or less pure cussedness of the stoker. The mechanical stoker may eliminate psychology from the matter, but even then after manufacturers are through hugging themselves in glee over finding a stoker that will keep steam up with bad coal, they may find that there is still more profit in using good coal.

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Doing the Hard Job

Certain jobs come to be regarded as hoodoos. They get talked over in meetings of engineers and no one wants to take them.

Sometimes they are the best jobs for a young man to get. When everything has run smoothly ever since a plant was first fired up there is no particular credit to either a new engineer or the old one for its performance. That is, there should be credit given but there is not. The man who makes his mark and impresses the world is not the one that comes along in time and stamps out a live cigar butt before the building catches fire but the one who comes at the last moment and "saves" the last man just as he was going to walk out unaided. This is all wrong. We worship the spectacular and we forget the man who really serves in a sensible way, but that is the way of the world and we will not have time to change it before we drop out of the running. So why not make something of it? If the world wants to be fooled why not fool it, especially when we can do it a good turn at the same time?

If a man can go into an engine room and straighten things out and put the plant where it will run every hour that the schedule calls for and do it where no one else succeeded, he is just the man that someone else is looking for. He probably has to do it with equipment that ought to be on the scrap heap, but if it is a stepping stone to something better why not do it? A man is better off with one earned failure back of him than he is with a dozen successful plants that "any fool" can run because many fools have. The thing that is worth while is to do something that not everyone can do. It is not always easy, it may be hard work and it may be hard thinking that brings success, but that is what our hands and our brains were given us for.

"He also serves who sits and waits" is a fine motto for an impatient man to hang over his desk but it has been the undoing of more than one engineer. Too often his job is a sitting and waiting job to such an extent that he feels that he can sit and wait until something happens that makes him stir, and no man can afford to do that no matter what his position. If a man cannot get a job that is big enough to keep him fully occupied he is to be pitied. The little jobs are for the little men, the old worn-out men who must have an easy letting down. The job for the young fellow is something that will keep him on his metal and that will not allow him to become an old man before his time, it is a job that someone else cannot do that he needs, and that he needs to conquer.

The Advancement Prospect

"Shall I look for advancement in my present position or shall I endeavor to get ahead somewhere else?" Many of us are asking ourselves this same question.

That there is a decided preference among most employers to promote their own employees, gives the cue to the seeker after success. He will be more apt to find promotion, responsibility, and a competence for old age with present employers than with others who know nothing of him.

It sometimes happens, however, that a man finds he has traveled as far as possible in his present position and has come up against a wall and that further advancement is prevented by favoritism, prejudice, the small size of the business or some other cause. What is he then to do? Where can he turn for success, the success which his present environment forbids?

Our answer to such would be: Look for your future in the employ of some young and growing concern, in a line of work in which your experience has made you valuable. In any case one will find it advisable to begin low, and secure the confidence of his employer. One must demonstrate his fitness for a superior position before he can be appointed to it. If he works hard and intelligently, and makes his employers' interests his own in whatever capacity he may be, then, if there are any real opportunities above him, promotion will take care of itself.

Viewing the Load Curve from Different Angles

In many generating plants the operating force never gets beyond the simple load curve plotted with kilowatts output as ordinates and hours of the day as abscissæ, so far as this method of station-performance analysis is concerned. It is desirable to plot other relations of the load to the operating period, and among these are the total daily output in kilowatt-hours contrasted with the days of the month; a curve showing the successive daily peaks and minimum loads for a month; a curve of average daily loads carried through a month, and a curve showing the number of hours each month that a given maximum load persists. Then there are a number of instructive comparisons which can be made with little trouble on a yearly basis, plotting the values against the months and comparing this year's performance with last year's. Progressive developments of monthly maximum loads plotted against time are interesting, and if one wants to include the capacity of generators in service at particular periods, it does not take long to get into the realm of really scientific plant operation.

Variations between different factors in plant service are well worth reducing to graphic form when a man has time to devote to this sort of analysis, and the far-sighted engineer is apt to find time for work of this kind, if he sees its value. Keeping such data up to the times in loose-leaf form or in blueprints which can be turned over to the "boss" upon receipt of some sharp-angled inquiry is a practice which bears cultivation. The value of the ordinary load curve is beyond question and needs no argument, and the development of special curves fitting each plant along the lines above hinted is a fascinating and profitable study.

War vs. Efficiency

Good engineers hold that energy should be conserved—not wasted. For centuries they have labored to get the maximum work out of a pound of coal, and the maximum effect from a pound of explosive. Through efficiency applied to engineering billions of dollars have doubtless been saved.

Through the steam engine and the development of other power apparatus science has advanced by leaps and bounds. During the last century, because of the availability of cheap power there has been more up-building than in the ten preceding centuries. We, therefore, have good reason to take pride in our power achievements.

However, it is lamentable that man should make use of power in a destructive way. Our European brothers have struggled hard, as hard as we, in their fight to conserve energy and natural resources. Now much of their work is being ruthlessly razed to the ground, and the pity of it all is that power is the chief instrument of ruination.

The explosives used in bombs, mines, and guns would find much better use in the blasting of roadways, foundations and tunnels.

The coal that propels the battleships would be of much greater benefit in propelling commerce boats. The needless burning of coal only brings us so much nearer to the exhaustion of the world's coal supply.

The iron and steel that makes up the guns and the armament should be put into efficient machinery—boilers, engines, motors, lathes, etc.

Finally the men, who are now killing each other, should be usefully and peacefully employed in making better use of nature's gifts for their own development and for the benefit of posterity.

*

Don't lose sight of the fact that our foreword this week is founded on fact. Except for the names it is a true story. More than that, it pictures a situation that really exists and needs correction. If you need to, take the tip and brush up on alternating-current practice

*

Any of our subscribers who receive post cards from u asking for information regarding boiler accidents wil confer a favor if they will fill these out and return them a promptly as possible. We are trying hard to bring ou the Boiler Explosion Table for the first half of this yea but are meeting with a great deal of difficulty in gettin the required information. Any help from our reader will be greatly appreciated.

Correspondence

Air-Compressor Testing

My attention has been directed to the article on this subject by W. C. Lancaster in the Jan. 6 issue of Power. I believe, in view of the rapidity with which compressed-air applications are increasing and the correspondingly increased attention which engineers are giving to air compressors and allied machinery, that several of the statements made should not remain unchallenged.

(1) This is the formula used for the flow of air through an orifice,

$$G = 0.53\,F\,\frac{P}{\sqrt{T}}$$

where

G = Flow of air in pounds per second;
F = Total area in square inches of all orifices;
T = Absolute temperature Fahrenheit of the compressed air in the orifice chamber;
P = Absolute pressure in pounds per square inch in orifice chamber.

While mathematically correct, it makes no allowance for friction or for the effects of and disturbances due to eddies. Both of these result in losses not accounted for by theory and necessitate an empirical coefficient of discharge in order to compute the actual quantity of air passing through the orifice. This coefficient, which depends upon the shape of the orifice, can be accurately determined only by experiment, but averages 0.942.

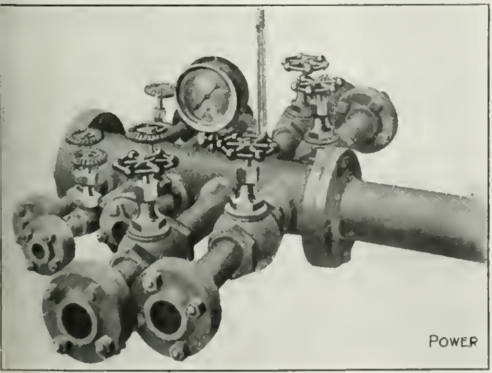
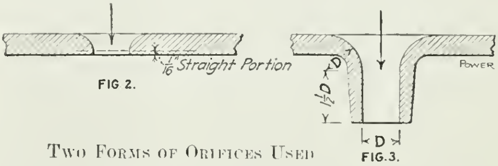


Fig. 1. For Measuring Flow of Air through Orifices

A rather elaborate series of experiments to ascertain the coefficient of discharge of air under various conditions was conducted several years ago by Sanford A. Moss and the results of his research are explicitly discussed in the *American Machinist*, Aug. 10, 1905; Sept. 20 and 27, 1906.

(2) Recommendation is made by Mr. Lancaster that the orifice manifold be connected to the discharge opening of the compressor. Such a method is obviously incorrect, for the pulsations in the pipe due to the intermittent discharge of air from the compressor causes disturbances and pressure fluctuations which prevent the attainment of that accuracy in air measurement which is so desirable. Tests conducted on large compressors furnishing air for the construction of the aqueduct in New York City showed such pressure variations that the results obtained were of value only for comparison with those obtained on other machines operating under similar conditions.

(3) The arrangement of the battery of orifices, as illustrated by Fig. 1, also shows a departure from the basic principles underlying and governing the design of orifices for accurately measuring the flow of air, and consequently makes the exact value of the coefficient of discharge still more uncertain.



Two Forms of Orifices Used

The formula given is based on the condition that the air enters the orifice at a velocity so low when compared with the discharge velocity as to be negligible; also, that the flow to the orifice is direct and not disturbed by constricted passages or sudden changes in direction with their resulting eddies. If these conditions do not prevail a correction must be made. The illustration shows the sharp turns necessarily made by the air in leaving the body of the manifold; also the globe valves, which are so close to the orifices as to make their effect on the discharge most pronounced. These valves are a necessity, but the eddies which they produce can be almost entirely overcome by considerably increasing the size of pipes in front of the orifices. This procedure would also decrease the air velocity to the orifices which, as already noted, has an important bearing on the accuracy of the results obtained. The manifold proper should be many times larger than shown and connected, not to the discharge line of the compressor, but to a receiver of ample capacity to minimize the effects due to a pulsating discharge. Pressure should be recorded, not in such a tank or in the manifold, but directly in front of each orifice used in the test.

(4) While the theoretical formula for flow furnished by the science of thermodynamics has no relation to the shape of the orifices employed, the form does affect the coefficient of discharge and should receive consideration. The shape used by Mr. Lancaster, reproduced in Fig. 2, has not been generally accepted by air-compressor builders, a more common form being as shown in Fig. 3. Here the length of the straight portion is one and one half times the diameter, with an inside radius equal to the diameter.

(5) Mr. Lancaster mentions the desirability of recording the temperature of both the air and the cooling water when entering and leaving the intercooler, but he fails to show the possible application of such readings to correct the apparent volumetric efficiency given by the formula already discussed. Efficiency of intercooling and humidity of the inlet air should always be considered, however, the affinity of air at high temperature for water vapor being concisely illustrated by Frank Richards and A. Hoffman in recent issues of POWER. Bearing this fact in mind, it is easy to conceive of a compressor producing perfect intercooling, showing by actual test a lower volumetric efficiency than a compressor in which an inefficient intercooler allows an excess of water vapor to be carried to the high-pressure cylinder and consequently through the orifice. Power consumption per unit quantity of air delivered indicates to the discriminating purchaser, however, which is the best machine and shows that the measure of volumetric efficiency alone is not the criterion by which a compressor should be judged.

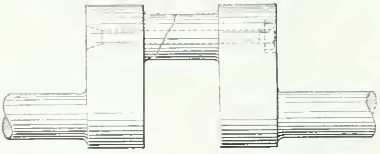
That the overall efficiency of the outfit considered by Mr. Lancaster in his summary of test results was very low when compared with present-day types of direct motor-driven compressors, is evident, when, even if we neglect the effects of humidity and apply only a coefficient of discharge of 0.912 (although the form of the orifice battery indicates a lower value) it is noted that the horsepower input to the motor per 100 cu.ft. of free air delivered at 100 lb. gage pressure equals 24.15. Compared with 15.31, the theoretical horsepower required for two-stage compression, this shows a total efficiency of compression of 63 per cent.

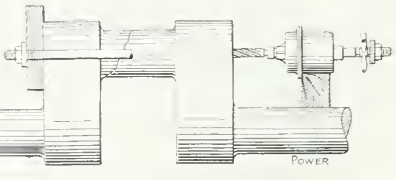
H. L. DEAN.

Brooklyn, N. Y.

Broken Crankpin Repaired

The illustration shows the way we repaired a broken crankpin on a 120-ton ice machine. The pin diameter was 9 in. and the pin was broken diagonally as shown.





AIR DRILL IN POSITION

It had run hot for several days, but no unusual noise indicated that it was broken. On disconnecting, we found the trouble.

To make a quick repair, we blocked and clamped an air-drill square with the crank. Two extension drills were made, the hole being started with the $\frac{3}{4}$-in. and the 2-in. was run through afterward. A taper reamer corresponding to the head of the bolt was used on one end of the pin and a flat cutter on the other end to recess for the head and nut to come flush with the crank web, as there was but little clearance in the crank case. After the bolt was put in and the pin drawn together a V-shaped groove was chiseled around the pin, following the crack. Since making this repair the engine has run continually for over a month making 44 r.p.m. and running perfectly cool.

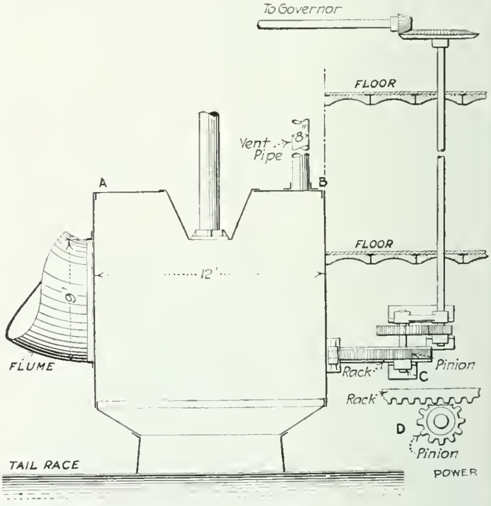
The job required two men 60 hours; 24 hours at double time and 36 hours at single time, and the total cost, including drills, reamers, etc. was $147.

J. H. CUNNINGHAM.

Toledo, Ohio.

Waterwheel Accident

Last winter, in a mill where there are two 51-in. waterwheels under a 17-ft. fall, one of the wheels gave trouble which at first looked like a mystery. There was a loud report, and half the top of the waterwheel casing lifted off, breaking at point A and allowing the water to flood the wheel-pit floor. The head gates were closed and things were looked over, but nothing was found to which the cause could be attributed.



BROKEN PINION CAUSED WATER-HAMMER

A man sent from the shop where the wheels were built could throw no light on the subject, as he had never seen anything like it before. The general manager sent for a master mechanic with extensive experience with waterwheels, who said our trouble was caused by air being pocketed under the head. We put in an 8-in. pipe as shown at *B* for a vent. After running a while, the following day, bang went the head again. This time it was found that at some previous time several teeth had been broken out of the rack pinion *C*. In operating the gate when the pinion got to the position shown at *D*, there was nothing to prevent the gate from closing quickly. This, of course, produced a water-hammer, and something had to let go. A new pinion was put on and castings made to fit over the crack in the head were secured with $\frac{1}{2}$-in. capscrews. Since then we have had no such trouble.

THOMAS SHEEHAN.

Williamstown, Mass.

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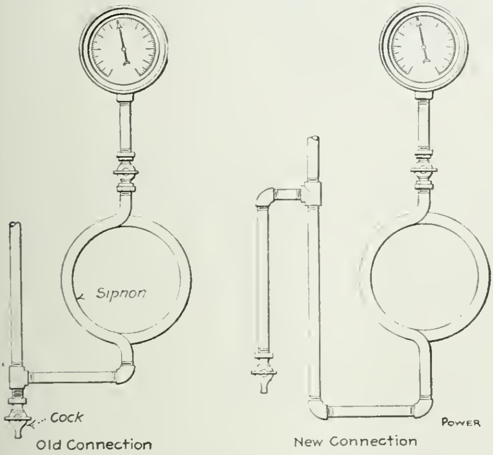
Steam-Gage Connections

In one plant the engineers frequently blew the water out of the steam-gage connections, and as the steam came in direct contact with the tubes, it distorted them and the gages read incorrectly. A lecture on steam gages helped the matter somewhat, but now and then someone would drain the lines again.



Old Connection New Connection

PROTECTING THE GAGE

I had all the gage connections changed as shown, so that no harm could be done. The steam fitter made all the changes one Sunday while the plant was shut down. I kept watch for a week, but I never saw a single drain cock opened, much to my chagrin, as the steam fitter had wagered the cigars that after making the change not one of the cocks would be opened in a week, and he was right. I have often wondered why.

C. E. ANDERSON.

Chicago, Ill.

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Diagrams from New Engines

Diagram Fig. 1 is from one of the best known high-speed Corliss type, four-valve engines, which has only been in service one month. The piston speed is 720 ft. per minute at 180 r.p.m., the stroke being 24 in. While this is good piston speed for economy, this diagram shows poor steam distribution, the admission is late and the steam is wire-drawn considerably, as is clearly evident.

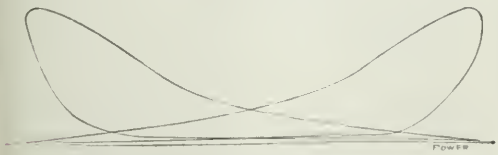

FIG. 1. INSUFFICIENT VALVE TRAVEL

It is clear that the movement of the valve is too slight for the required steam and small movement means poor wearing qualities.

Diagram Fig. 2 is from a four-valve Corliss type engine, controlled by a variable eccentric. The piston speed is 690 ft. per min. at 230 r.p.m., the stroke being 18 in. This engine has an advantage in that the piston speed is considerably lower and the valve motion is far superior. These diagrams show the operation of the engines as turned over by the erecting man.

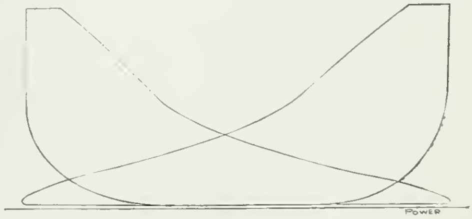

FIG. 2. SUPERIOR VALVE MOTION

C. R. McGAHEY.

Baltimore, Md.

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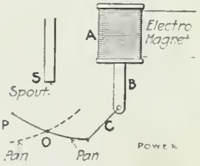
Alternating-Current Magnet Burnouts

The steady current that a given direct voltage will maintain through a solenoid depends upon the resistance of the winding irrespectively of whether the latter includes an iron core or not. The current that an equivalent alternating voltage will maintain through the solenoid depends upon the impedance of the coil, which in turn depends not only upon the resistance of the winding, but upon whether the winding includes a magnetic circuit, and, if it does, upon whether the iron of the magnetic circuit is continuous or is broken by an air gap. It follows, then:



PAN CONTROLLED BY ELECTROMAGNET

(1) If to a coil designed for use with an iron core, rated alternating electromotive force, be applied without the core, the coil will burn out because the current will be abnormal.

(2) If to a solenoid designed to operate with a core air gap of a certain maximum thickness, rated alternating voltage be applied continuously or too continually, the coil will be burned out; how long it will last under these conditions will depend upon how often or how continuously the electromotive force is applied.

Therefore, a contactor operated by an alternating current will take a much heavier current when it is open than when closed. These possible conditions of abuse are illustrated by the following:

An operator burned out a brake coil of an electrically operated hoist. He wound a new one to replace it, but this coil and several others that he wound were burned out by the test he gave them to insure that they were all right before installing them. He finally became tired of winding coils and sent for assistance, whereupon it was found that the preliminary test consisted in applying full rated voltage to each coil as it lay on the table without any magnetic circuit to take the place of the one that it would have had when installed on the crane. Had the operator included an ammeter in his test circuit, the current would have surprised him, and the ammeter, too, probably, unless he had happened to get one that was big enough.

In the accompanying diagram, *S* is a spout to deliver purifying liquid to the water delivered by a motor-driven filter outfit; *P* is a tin pan pivoted at *O* so that the pan may take either of the positions indicated. When the plunger *B* of the electromagnet *A* is down, the pan is in the position represented by the full line, and when *B* is up, the pan is in the dotted position. Magnet *A* was so connected that when the motor started, *A* would be energized, and the pulling up of *B* would tilt the pan to the dotted position, thereby deflecting the purifier into the proper intake. Stopping of the motor would simultaneously deënergize the magnet and permit gravity to restore all parts to the release position in which the purifier was deflected to a receptacle on the opposite side.

The operator had had several magnet coils burn out and he thought that the cause was high voltage. Investigation proved that the trouble was due to a rigid connection between rod *C* and the pan. This caused *B* to bind at the lower end of its travel, and the coil had not sufficient strength to release it. Under this condition, the coil had practically no core within it, hence the abnormal current taken burned it out. Insertion of a piece of light chain between the rod *C* and the pan *P* stopped the trouble.

J. A. Horton.

Schenectady, N. Y.

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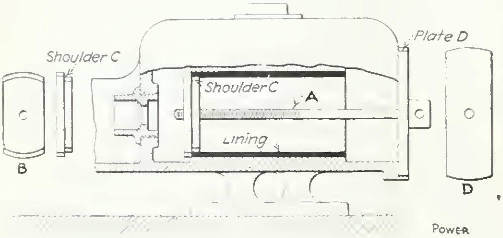
Removing Pump Linings

The illustration shows how I have several times removed the worn lining from the water end of a pump. The heavy bolt *A* is threaded for a considerable length.



Parts Assembled

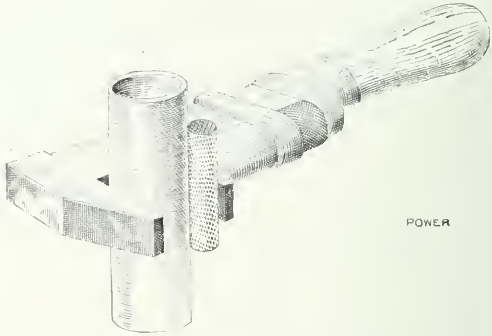
Plate *B* is drilled and tapped to match. Shoulder *C* is an easy fit into the lining and the ends of the plate just clear the bore of the cast-iron body. Plate *D* is used to take the strain on the bolt at the head. After assembling as shown, the lining may be pulled as far as plate *D*, when it becomes necessary to put in blocking between the plate and the pump. This same rig may be used to pull in the new lining by reversing, but care should be taken to protect the stuffing-box in so doing.

George J. Little.

Passaic, N. J.

Improvised Pipe Wrench

An old trick worth knowing is illustrated. A short piece of a round file and a monkey-wrench may be used to turn a pipe, in the absence of anything better. The wrench is opened enough to span the pipe and the file put in parallel to the pipe, as shown. When pressure is applied to the wrench the file rolls in firmly between the wrench jaw and pipe, causing a grip which holds without the least slippage. A slight backward movement will release the wrench instantly.



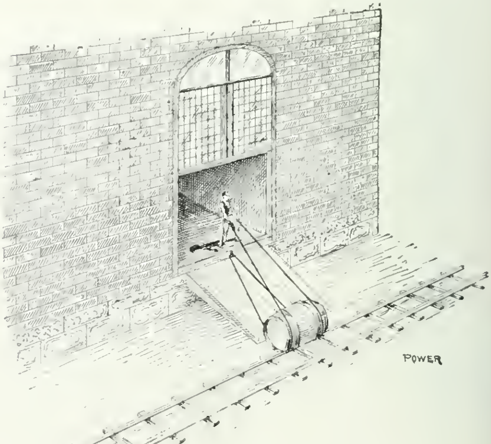
Wrench and File in Position

Whitinsville, Mass. A. C. Nella.

⁂

Rolling Barrels up an Incline

The illustration shows the incline up which barrels of oil had to be rolled at our plant. It took two husky men to manage a barrel containing 50 to 55 gal. One of the oilers finally drove a hook into the door sill, out of the way. Then, taking a long rope, he doubled it and hooked it to the door sill and passed it around under the barrel near each end, and back to the doorway, as shown. The barrel could then be guided and pulled up the incline easily by one man.



A Hitch to Roll the Barrel

Kittanning, Penn. R. G. Curren, Jr.

Inquiries of General Interest

Rectifier in an Absorption System—What is the office of the rectifier in an absorption system of refrigeration?

C. R. H.

To condense any water vapor carried along with the ammonia vapor from the generator, the liquid thus condensed being drained off or returned to the generator.

Opening Glass Gage Connections—In opening the connections for a water-gage glass to a boiler after they have been turned off, why should the lower valve be opened first?

R. G. M.

Opening the lower valve first would warm up the gage-glass more gradually than to turn the steam in first and thereby be less likely to cause the glass to break.

Advantage of Independently Driven Air Pump—What is the advantage of an independent air pump?

E. M.

For large powers, an independently driven air pump has an advantage over a direct-connected pump in requiring less power at reduced engine loads, as the speed of the air pump is under separate control to suit the requirements of the condenser.

Bleeder Turbine—What is a bleeder turbine?

H. D. R.

A steam turbine which is adapted to be bled at one of the intermediate stages, steam being taken from it as is often done from the receiver of a compound engine for heating or industrial purposes.

Replacing Tube in Water-tube Boiler—If a tube in the center of the middle header of a B. & W. type water-tube boiler should explode, would it be necessary to remove other tubes in order to remove and replace the damaged tube?

H. A. L.

No, for opposite each tube end in the headers is a handhole of sufficient size for cleaning and removing or renewing a tube without disturbing other tubes.

The Half-Stroke Which Requires Less Time—In which end of the cylinder of a reciprocating engine is one-half of the stroke of the piston accomplished in the least time?

M. D.

Less than one-quarter of the revolution of the crank is performed by one-half stroke on the head end so that with uniform rotation less time is required for accomplishing one-half stroke of the piston in that end of the cylinder.

Performance of Condensers—What are the leading factors upon which it is usual to base the performance of condensers?

J. E. B.

The performance is based on the number of inches of vacuum to be obtained when condensing, per hour, a stated weight of steam of given temperature, and handling, during the same period, a given quantity of condensing water supplied at a stated temperature.

Steam Liberating Surface per Boiler Horsepower—What should be the steam liberating surface in boilers per horsepower?

H. J. M

With ordinary good circulation, about ¾ sq.ft. of steam-liberating surface per boiler horsepower is satisfactory for the generation of dry steam in fire-tube boilers, and about ⅜ sq.ft. of steam-liberating surface per horsepower has given good results in water-tube boilers having steam drums which are not subjected to the greatest intensity of the fire.

Gage Cock Shows Steam—When all water column connections of ample size are clear and the water glass shows three gages of water, what would cause the gage cocks to show only two gages of water in a boiler?

S. J. A.

With high boiler pressure and water only a little above the third gage cock, the discharge of water from the gage cock at high velocity would be broken up into a fine spray which could easily be mistaken for steam. The uncertainty is one of the principal reasons for placing greater reliance on a glass gage.

Legal Decision Reports—Under "Recent Court Decisions," there are references to publications evidently containing fuller reports of the cases. Where can these be obtained?

K. L. W.

The publications referred to are the various weekly Reporters covering the United States, as follows: Atlantic, Pacific, Federal, Northeastern, Northwestern, Southeastern, Southwestern, Southern and Supreme Court Reporter (semi-monthly) and the New York Supplement. These belong to the National Reporter System and are published by the West Publishing Co., 50 West Third St., St. Paul, Minn. Copies can be obtained direct from the publisher or from any dealer in law books, or can be consulted in any law library.

Neglecting Area of Piston Rod—In figuring from indicator diagrams the horsepower developed by an engine, what is the usual error of computation resulting from neglecting the reduction of piston area by the cross-sectional area of the piston rod?

M. G.

The average size of piston rods of steam engines is about ⅙ the diameter of the piston, thereby reducing the effective area of the piston about $^1/_{36}$, or about 2.8 per cent. As for engines without tail rods, this reduction would apply only to the crank side of the piston, then, with the same mean effective pressure indicated in each end of the cylinder, neglecting the correction for the cross-sectional area of the piston rod would make the computation result about 1.4 per cent. too large.

Terminal Pressure with ¼ Cutoff—With initial pressure at 100-lb. gage pressure and 5 per cent. clearance, what would be the terminal pressure with cutoff at 25 per cent. of the stroke, assuming isothermal expansion

H. H.

Gage pressure of 100 lb. per sq.in. would be equivalent to

$$100 + 14.7 = 114.7 \text{ lb. absolute}$$

With 5 per cent. clearance and cutoff at 25 per cent. of the stroke, the volume of steam present at the time of cutting off would be 5 + 25 or 30 per cent. of the piston displacement, and the total volume after expansion would be 100 + 5 or 105 per cent. of the piston displacement. As the terminal pressure would be inversely as the volumes before and after expansion, then the terminal pressure would be

$$\frac{30}{105} \times 114.7 = 32.77 \text{ lb. absolute,}$$

or

$$32.77 - 14.7 = 18.07 \text{ lb. gage pressure.}$$

Boiler Efficiency—What is the efficiency of a boiler and how is it determined?

T. B.

There are two methods of defining and estimating the efficiency of a boiler, one being based on combustible and the other being based on coal. According to the first,

$$\text{Efficiency of a boiler} = \frac{\text{Heat absorbed per lb. of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

This is the standard of comparison for all tests, and is the one which is understood to be referred to when "efficiency" alone is used without qualifications. The "heat absorbed per pound of combustible" is to be calculated by multiplying the equivalent evaporation from and at 212 deg. F. per pound of combustible by 970.4 and the calorific value of 1 lb. of the combustible is to be determined by a coal calorimeter or estimated from the analysis of the coal.

When the purpose is to include boiler and grate together

$$\text{Efficiency of the boiler and grate} = \frac{\text{Heat absorbed per lb. of coal}}{\text{Calorific value of 1 lb. of coal.}}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXVII

LAST LESSON'S ANSWERS

121. The time of flight is found from equation (70), where $T_1 = \frac{2V \sin a}{g}$. In this case the angle a = 45 deg. and $\sin a = 0.707$; also V = 1200 ft. per sec., hence $$T_1 = \frac{2 \times 1200 \times 0.707}{32.16} = 52.8 \text{ sec.}$$

122. The projectile will strike the ground at a distance from the gun equal to the horizontal range R, which is determined from equation (71), where $R = V \cos a \times T_1$: hence

$R = 1200 \times 0.707 \times 52.8 = 44{,}795$ *ft.*, or 8.48 *miles.*

123. From equation (73), $H = \frac{V^2 \sin^2 a}{2g}$. In this problem V = 1200 ft. per sec.; $\sin a = 0.707$, hence $$H = \frac{1200 \times 1200 \times 0.707 \times 0.707}{2 \times 32.16} = 11{,}190 \text{ ft. or } 2.12 \text{ miles}$$

124. The range is easiest determined by first solving problem 125, to ascertain the time of flight. From equation (75), $-H = V \sin a \times T - \frac{1}{2} g \times T^2$, where H is the elevation of the point of projection and in this case is equal to 500 ft. Substituting the given values in equation (75) there results, $-500 = 1200 \times 0.707 \times T - 16.08\, T^2$ or, $T^2 - 52.76\, T = 31.09$, which is a quadratic equation and may be solved by adding 695.9 to both sides of the equation, so as to make the left side a perfect square, thus,

$$T^2 - 52.76\, T + 695.9 = 31.09 + 695.9 = 727$$

and taking the square root of both sides, there results,

$$T - 26.38 = 26.96$$

or, $$T = 26.96 + 26.38 = 53.3 \text{ sec.}$$

The range is dependent upon the horizontal component of the velocity and the time of flight, or, as given by equation (71), $R = V \cos a \times T_1$; where V = 1200 ft. per sec., and T_1 = 53.3 sec., therefore

$R = 1200 \times 0.707 \times 53.3 = 45{,}220$ *ft.*, or 8.58 *miles.*

125. In problem 124 the total time of flight was found to be 53.3 sec., which, it will be noted, is just about one-half second longer than the time found in problem 121.

ROTARY MOTION

In equation (47), it was shown that the force required to produce an acceleration of a feet per second per second on a mass of M pounds was equal to $M \times a$. As the mass becomes greater the force required to produce a given acceleration also becomes greater; that is, the force is directly proportional to the mass, *assuming that the mass is moving in a straight line.*

In the case of rotating bodies, not only must the mass be considered, but also its distance from the center of rotation. Thus a small force acting at a great distance from the center of rotation may produce the same "torque" or turning moment as a large force acting at a small distance. The resistance to rotation of a given body, then, depends both on the mass of the body and the distribution of the mass relative to the center of rotation. It is evident from experience that it is much easier to set in motion a flywheel whose mass is concentrated in its hub than it is to set in motion one whose mass is concentrated in its rim. Moreover, it must be apparent that the linear acceleration of a given mass is also dependent upon its distance from the center of rotation. Thus, if two wheels of the same mass, but of different diameters, are to be brought up to speed in the same time, the linear accelerations of their rims must be different in order to produce the same angular acceleration.

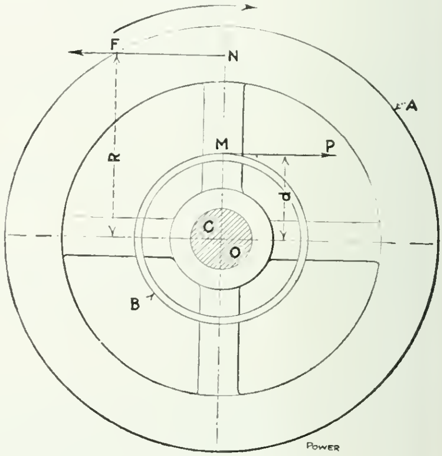


FIG. 79.

In equation (26) it was shown that the angular velocity of a body, expressed in radians, was equal to the linear velocity divided by the radius. In like manner, it may be shown that the angular acceleration in radians is equal to the linear acceleration in feet per second per second, divided by the radius in feet. Thus, let

a = The linear acceleration in feet per second per second;

a_1 = The angular acceleration in radians per second per second, and

R = The radius of rotation in feet, then,

$$a_1 = \frac{a}{R} \text{ or, } a = a_1 \times R$$

As a general rule, the acceleration of rotating bodies is expressed in revolutions per second per second, and as there are 2π radians in the circumference of a circle (see lesson XV), it follows that $a = 2\pi AR$, where A = the increase in revolutions per second per second. In the case of a flywheel, each separate particle will be located at a fixed distance from the center of rotation and, as there is an infinite number of particles, there will be an infinite number of radii and each particle will have a different linear velocity. For this reason the mass of the wheel is assumed concentrated at a certain point, so that the resistance which the wheel would offer to a change of angular velocity will remain the same. The distance from this point to the center of rotation is called the *radius of gyration* of the wheel. The value of the radius of gyration of various sections may be found by reference to any engineers' handbook. In the case of flywheels with heavy rims the hub and arms are neglected and the weight of the rim only is considered. In such cases, it is customary to consider the radius of gyration as the distance from the center of the wheel to the middle of the rim.

In Fig. 79, assume a heavy wheel A to be mounted on the shaft C, to which is keyed the pulley B. A force of P pounds is applied at the rim of the pulley. It is desired to find the value of this force in terms of the weight of the wheel in order to give a definite angular acceleration to the wheel. First assume that the mass M of the wheel is concentrated at the center of the rim at a distance of R feet from the center of the shaft. It must be evident that the inertia of the rim will act in a direction opposite to that in which the wheel is to move.

Let F = the force of inertia which, from equation (47), is equal to the mass of the rim times the linear acceleration, or $F = M \times a$. Now from the conditions of equilibrium, the algebraic sum of the moments about the point O must equal zero. Thus, $F \times R = P \times d$, and as $F = M \times a$, it follows that, $M \times a \times R = P \times d$. Also as previously proven, the linear acceleration a is equal to $2\pi A \times R$; therefore, substituting this value in the above equation, there results,

$$M \times 2\pi \times A \times R \times R = P \times d, \text{ or,}$$

$$2\pi \times MR^2 \times A = P \times d \qquad (76)$$

Expressed in gravitational units, the equation becomes,

$$2\pi \times \frac{W}{g} \times R^2 \times A = P \times d \qquad (77)$$

where,

W = The weight of the rim in pounds;
R = The radius of gyration in feet;
A = The angular acceleration in revolutions per second per second;
P = The force required in pounds;
d = The moment arm in feet of the force P, and
g = Acceleration due to gravity = 32.16.

The quantity MR^2 is called the moment of inertia of the body. To determine this quantity, it is necessary to consider the body as being made up of an infinite number of small particles, and to multiply each of these particles by the square of its distance from the center of rotation, and then add all these small quantities together, which sum gives the moment of inertia.

The moment of inertia of bodies of uniform density may be determined by the aid of calculus, which is beyond the scope of this work. However, these values may be found by reference to handbooks.

In the design of flywheels, it is desired to have as large an inertia effect as possible with a given weight. For this reason the moment of inertia is made large by placing most of the metal in the rim and making the diameter of the wheel relatively large. The moment of inertia of the hub and the arms is comparatively small, and, therefore, in the following problems only the inertia effect of the rim will be considered.

STUDY QUESTIONS

126. The point N on the wheel A, Fig. 79, is 5 ft. from the center of the shaft. The wheel starts from rest and at the end of 2 min. is running at 75 r.p.m. Find the linear acceleration of the point N in feet per second per second.

127 (a) Find the angular acceleration of the point N in revolutions per second per second. (b) Do all points in the wheel have the same angular acceleration?

128 The outside diameter of a cast-iron flywheel is 12 ft. The rim is 8 in. thick and the face of the wheel is 10 in. Find the weight of the rim and its radius of gyration.

129. What force P, acting at a distance of 2 ft. from the center of the wheel, will be required to bring the wheel up to a speed of 90 r.p.m. in 1½ min. Neglect the weight of the hub and the arms.

130. Assume the wheel running at 120 r.p.m. What braking force P, acting at a distance of 18 in. from the center of the shaft, will be required to reduce the speed to 60 revolutions in one minute?

⁂

Operation of Boiler-Inspection Laws

By A. L. H. Street*

SYNOPSIS—A review of court decisions in which the scope of inspection regulations has been considered.

⁂

In view of the movement toward the establishment of uniform boiler-inspection laws throughout the several states, it is interesting to note the points related to such legislation which have been before the appellate courts of the country.

The relationship between state and federal jurisdiction was involved in a prosecution which was brought by the Commonwealth of Massachusetts against the Breakwater Co., 100 *Northeastern Reporter*, 1034. In reversing a conviction of the company for a claimed violation of the Massachusetts inspection laws, the Supreme Judicial Court of that state decided the following points:

The provision of the law for the inspection of "all steam boilers, and their appurtenances except . . . boilers under the jurisdiction of the United States" does not exclude from the operation of the statute everything over which the United States, by the fullest exercise of its powers under the constitution, might assume authority. "There is an extensive field of human activity over which the states may exercise jurisdiction, until the United States through Congress asserts its power."

Such a law as this must not be given a narrow interpretation, since it relates to the "safety of large numbers of people and considerable amounts of property."

Boilers on seagoing barges are not subject to the state inspection law, but, in the absence of regulation by the United States, a provision of a state law such as that above quoted extends to a boiler on a barge used solely for loading and unloading cargoes, and not for purposes of propulsion. Giving the law this interpretation does not make it invalid as an interference with interstate or foreign commerce. "The general purpose of the statute is so humane that it cannot be held to be an imposition upon navigation."

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*Attorney at law, St. Paul, Minn.

Accordingly, the Supreme Judicial Court decided that the question whether the Breakwater Co. had violated the law by failing to have the boiler on its barge inspected depended upon whether the barge was a seagoing one.

The principle that a boiler must be permanently located within the jurisdiction which attempts to regulate it finds support by analogy in the case of People vs. Prillen, 65 *Northeastern Reporter,* 947. In that case the New York Court of Appeals reversed a conviction of defendant on a charge of operating two boilers without having obtained the certificate of qualification required by the New York City charter. It appeared that the boilers were operated on a scow by a New Jersey company within the limits of New York City in removing an obstruction from the East River. The Court of Appeals, referring to the charter provision, said: "This section evidently contemplates the inspection of such steam boilers as are permanently in use in the city of New York."

By decision of the Minnesota Supreme Court in the case of State vs. Justus, 94 *Minnesota Reports,* 207, the Minnesota inspection law has been held not to extend to the boilers of steam-heating plants in private buildings. The court said:

"The act was designed for the better protection of life and property by providing for the inspection of steam vessels and steam boilers used to generate power for the operation of machinery, and requiring that all persons having charge of the operation of the same and masters and pilots of steamboats on inland water of the state be competent and qualified for the service."

* *

Boiler Laws and Their Application to the Manufacture of Stock Boilers

By G. G. Dana, M. E.

SYNOPSIS—Comments on existing boiler laws and rules from the viewpoint of the manufacturer, and suggestions tending toward the standardization of design and construction.

*

Safety is the basis for many reforms and to this end boiler laws have been or are being enacted by several states and cities as well as several of the Canadian provinces. Laws of this kind are justified, but there should be enough scope to meet the various conditions, and they should not unnecessarily hamper.

Massachusetts and Ohio have laws almost identical in their application, although the arrangement of subjects is more systematic in the Ohio rules.

The rules of Detroit, Mich., and Manila, P. I., are patterned after the Massachusetts rules.

The Canadian provinces of Alberta, Ontario and Saskatchewan have boiler laws which are practically alike, but differ widely in many respects from those of Massachusetts and Ohio.

To avoid repetitions in what follows, the Ohio rules will be mentioned when they are the same as those of Massachusetts, Detroit and Manila, and Alberta, where they are the same as Ontario and Saskatchewan; separate mention being made on subjects where differences occur in the rules.

Most of the laws are good individually and a boiler constructed in compliance with any one of them would be safe and durable, but it is difficult to build stock boilers which will meet the requirements of all of them.

The article on "A Comparison of Boiler Standards" by Mr. MacDonald in Power, May 19 issue, has covered many items, but there are some other points.

Under stamping and identification, the firm's serial number must be stamped on all Massachusetts standard boilers. I have been given to understand by the chairman of the Board of Boiler Rules in Boston that this number must be in a separate series, which shall start with one and shall comprise only the boilers built Massachusetts standard. This requirement makes it necessary for the manufacturer to keep track of each boiler under two numbers, making an extra amount of clerical work with the records.

This is all right for boilers built to order, but for stock boilers it means that each one built must be stamped and a report filled out and sent to each state to which there is a probability of the boiler being shipped.

The Canadian rules require that only boilers actually shipped into the province shall have an affidavit of manufacture sent with the boiler. The Ohio and Massachusetts rules should be modified to require that manufacturers keep an accurate record of all materials used in each boiler while the boiler is being built; then from this record the data report could be filled out and the boiler stamped, under the authority of the inspector, after the destination of the boiler is known. This would eliminate much cumbersome procedure, and also reduce the files of the Board to the actual number of boilers shipped into the state.

Materials

A comparison of the kind of material can best be made by referring to Table 1.

Only the Ohio and Massachusetts rules specify the brand of steel; the Canadian rules lay more stress on the physical and chemical properties.

Shells, etc., by the Ohio rules must be of firebox steel, while Alberta allows the class which is known to the trade as flange steel. In Ohio stayed surfaces may be of any grade of openhearth steel, while Alberta requires them to be the same as shells unless they are exposed to the fire, in which case, they must be firebox steel. Fireboxes and combustion chambers may be of any of these three brands of steel in Ohio.

The per cent. of elongation in 8 in. should be allowed to vary as by the Saskatchewan rules, being determined by dividing 1,450,000 by the tensile strength, so that as the tensile strength increases, the ductility decreases which is a natural result with most kinds of steel. This sliding-scale method is used by the American Society for Testing Materials, as being equitable to purchaser and manufacturer. The minimum amount of phosphorus is allowed to be higher when the steel is made by the acid process than when the basic process is used. It is claimed that the acid process makes a better quality of steel, but that it is difficult to keep the phosphorus content down as low as may be done with the basic process.

TABLE I. GIVING COMPARISONS OF THE KIND OF MATERIALS REQUIRED FOR THE PARTS OF A BOILER BY THE VARIOUS RULES

Part of Boiler	Properties Considered	Ohio & Massachusetts	Alberta & Ontario	Saskatchewan	British Columbia
Shells, domes, drums and butt straps.	Brand	Fire-box steel	...	...	..
	Tensile strength, lb. per sq.in.	52,000 to 62,000	55,000 to 65,000	55,000 to 65,000	55,000 to 72,000
	Elongation in 8″ not less than.	26%	22%	*26% to 22%	20%
	Phosphorous shall not exceed..	0.03%	0.04%	Basic .04, acid .05%	0.04%
	Sulphur shall not exceed..	0.04%	0.04%	0.05%	0.04%
	Manganese	0.30% to 0.60%			
Heads or any plates requiring staying or flanging.	Brand	Flange, fire box or ex. soft	May be the same as for shell	May be the same as for shell	
	Tensile strength, lb. per sq.in.	45,000 to 65,000			55,000 to 67,000
	Elongation in 8″ not less than.	25, 26, or 28%			23%
	Phosphorous shall not exceed.	0.04, 0.03, or 0.04%			
	Sulphur shall not exceed.	0.05, 0.04, or 0.04%			
	Manganese	.30 to .60%; .30 to .50%			
Fire-box or combustion chamber.	Tensile strength, lb. per sq.in.	May be the same as for heads	52,000 to 62,000	52,000 to 62,000	55,000 to 65,000
	Elongation in 8″ not less than.		26%	*28 to 23.4%	25%
	Phosphorus shall not exceed..		0.035%	Basic .035, acid .04%	
	Sulphur shall not exceed..		0.035%	0.04%	
Rivets.	Brand	Extra soft	...	..	..
	Tensile strength, lb. per sq.in.	45,000 to 55,000	45,000 to 55,000	45,000 to 55,000	55,000 to 65,000
	Elongation in 8″ not less than..	28%	28%	28%	25%
	Phosphorous and sulphur not to exceed..	0.04%	0.04%	.045%	.....
Stay bolts, through stays and braces. Weldless steel.	Tensile strength, lb. per sq.in..	62,000 maximum (certified)	52,000 to 62,000	52,000 to 62,000	55,000 minimum
	Elastic limit, lb. per sq.in..	† Not less than ½ T.S.	33,000 maximum	33,000 maximum	33,000 maximum
	Elongation in 8″ not less than	28%	25%	25%	22 to 25%
Stay bolts, through stays and braces. Weldless iron.	Tensile strength, lb. per sq.in..		46,000 minimum	46,000 minimum	46,000 minimum
	Elastic limit, lb. per sq.in....	†	26,000 minimum	26,000 minimum	26,000 minimum
	Elongation in 8″ not less than..	...	22%	22%	20 to 22%

*By the Saskatchewan rules the elongation per cent. in 8″ may vary inversely as the strength of the material, being determined by dividing 1,450,000 by the tensile strength $\left(\frac{1,450,000}{T.S.}\right)$ and the phosphorous contained in the steel may have a higher percentage when made by the acid process than when the basic process is used.

†Ohio and Massachusetts rules do not give any requirements for stay bolt material, either iron or steel. When a certified report of the material accompanies the data report the qualities shall be as given in this table.

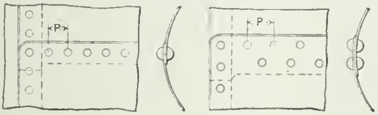

FIG. 1 LAP JOINT-SINGLE RIVET FIG. 2 LAP JOINT-DOUBLE RIVETS

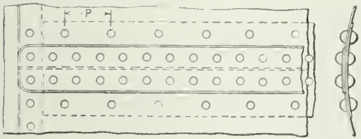

FIG. 3 BUTT JOINT-DOUBLE RIVETED-OHIO AND MASSACHUSETTS

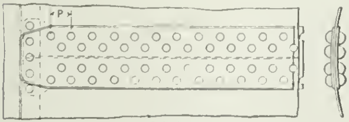

FIG. 4 BUTT JOINT-DOUBLE RIVETED-CANADIAN

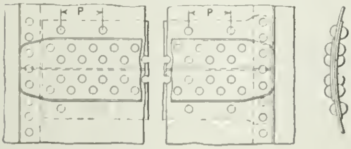

FIG. 5 FIG. 6

BUTT JOINT - TRIPLE RIVETED
OHIO & MASSACHUSETTS CANADIAN

PLATE I. RIVETED JOINTS

The longitudinal seam is a subject of disagreement among the various rules. Ohio requires the butt joint, Plate I, Fig. 3 or 5, on all boilers over 36 in. and on any boiler, regardless of size which is to carry over 100 lb. per square inch. Under 36 in. the lap joint as shown in Figs. 1 and 2 may be used.

The Canadian rules do not prohibit the use of lap joints but restrict their use by penalizing them by increasing the factor of safety. The butt joints allowed by the Canadian rules are shown in Figs. 4 and 6. They do not allow the double-riveted butt joint, as shown in Fig. 3, but require that they shall have both straps of equal width. Fig. 3 is a good kind of joint and well adapted for use on small boilers, while Fig. 4 is more expensive and less efficient, owing to the close spacing of the rivets in the outer row, weakening the shell at this line. Joints, Figs. 5 and 6, are essentially the same except that Fig. 6 has the inner butt-strap scarfed to take the rivets in the circumferential seam. Ohio and Massachusetts do not require this, nor do they object to it.

There should be a rule governing the distance between the rows of rivets, as it is possible to put them so close together that the sum of the two diagonal ligaments between the rivet holes will be less than the ligaments between the two rivet holes in one row. A joint can be made which will figure a higher efficiency than it possesses. The Canadian rules are rather cumbersome and involved, but they do cover this weakness found in the Ohio rules. A rule which requires that the sum of the two diagonal ligaments between the holes in adjacent rows shall be greater than the ligament between two holes in the same row by at least ten per cent. is recommended.

RIVET HOLES

The Ohio rules require that nearly all rivet holes shall be drilled full size or punched under size, then drilled or reamed to full size with plates, butt straps and heads bolted up in position.

The Alberta rules prefer rivet holes drilled from solid plates, but permit punching and reaming certain sizes and are more practical in this respect than the Ohio rules when applied to riveted joints of standard construction. For British Columbia all rivet holes must be made perfectly true and fair by clean-cutting punches or drills; the sharp edges and burrs are to be removed by slight counter-sinking and burr reaming.

It is therefore suggested that the rules now in force in Ohio and Massachusetts be modified to read that rivet holes, when punched, shall be $\frac{1}{4}$ in. less than full size in plates over $\frac{5}{8}$ in. in thickness; $\frac{3}{16}$ in. less than full size in plates over $\frac{3}{8}$ in. and not exceeding $\frac{5}{8}$ in. in thickness; and $\frac{1}{8}$ in. less than full size for plates $\frac{3}{8}$ in. in thickness and less. If this modification of these rules were allowed it would bring the practical application of the Canadian and States rules to uniformity.

In a case where two sheets of unequal thickness are riveted together in a lap joint, it is recommended that the amount the holes are required to be reamed out shall be determined by the thinner plate. The thicker sheet under the same condition always is stronger than the thinner, and therefore does not require any more reamed out. When the holes which come together are the same size it makes fitting up much easier and does not in any way impair the strength of the joint.

STAYED SURFACES

This subject has been covered quite thoroughly by Mr. MacDonald, but a few other points may be brought out.

TABLE 2. SHOWING COMPARISON OF WORKING PRESSURES ALLOWED ON FLAT SURFACES WHEN SCREWED STAY BOLTS WITH RIVETED ENDS ARE USED

Thickness of Plate	Pitch of Stay Bolts	Area of Surface, Sq.In.	Allowable Working Pressure, Lb. per Sq.In. Ohio and Mass.	Alberta, Ont. & Sask.	British Col
$\frac{5}{16}$	$4\frac{1}{2}$x$4\frac{1}{2}$″	$20\frac{1}{4}$	170	138	222
$\frac{3}{8}$	5 x5″	25	170	161	245
$\frac{7}{16}$	$5\frac{5}{8}$x$5\frac{5}{8}$″	31.64	170	173	253
$\frac{1}{2}$	$6\frac{1}{8}$x$6\frac{1}{8}$″	37.51	170	205	270
$\frac{9}{16}$	$6\frac{3}{4}$x$6\frac{3}{4}$″	45.56	170	213	274
$\frac{5}{8}$	$7\frac{1}{4}$x$7\frac{1}{4}$″	52 56	170	228	287
$\frac{11}{16}$	$7\frac{7}{8}$x$7\frac{7}{8}$″	62 02	170	234	290

In this table, 170 lb. per square inch is taken as a working pressure and the pitch as given by the table in the Ohio rules. The allowable pressures for these pitches for others are computed from the formulas given in their rules. It will be noticed that Alberta allows the lowest pressure on the thin plates and is more liberal on thicker plates, etc.

The subject of uneven and irregular spacing of staybolts is one that is of importance on medium and small sizes of boilers. In laying out boilers of this kind it is often impossible to arrange the stays in uniformly spaced rows, consequently some provision should be made for unequal pitches and irregular spacings as is done by the Canadian formula which works out so that whether applied to regular or uneven spacing, the results will be the same, while for irregular spacing the area supported will be slightly less than with regular spacing.

These rules allow the substitution of $\frac{Sh^2 + Sv^2}{2}$ for S^2 when the horizontal and vertical pitches are not alike. Sh and Sv representing the horizontal and vertical spacing of stays. This substitution with uneven spacing results in a reduction of area supported for a given pressure in proportion to the variation between the two spacings.

In case there is a portion of a boiler which does not permit of regular or uneven spacing of staybolts the laws in the Canadian Provinces allow the substitution of

$$\frac{(dS_1 + dS_2)^2}{8} \text{ for } S^2$$

in which dS_1 and dS_2 are the diagonal distances between centers of staybolts.

The Ohio and Massachusetts rules do not provide for irregular spacing, but require that the pressure shall be figured from the greatest pitch.

The difference in the results obtained by the various formulas can best be compared by referring to Plate II, in which the upper figures 1, 2 and 3 represent equal areas with the results as obtained by the various formulas

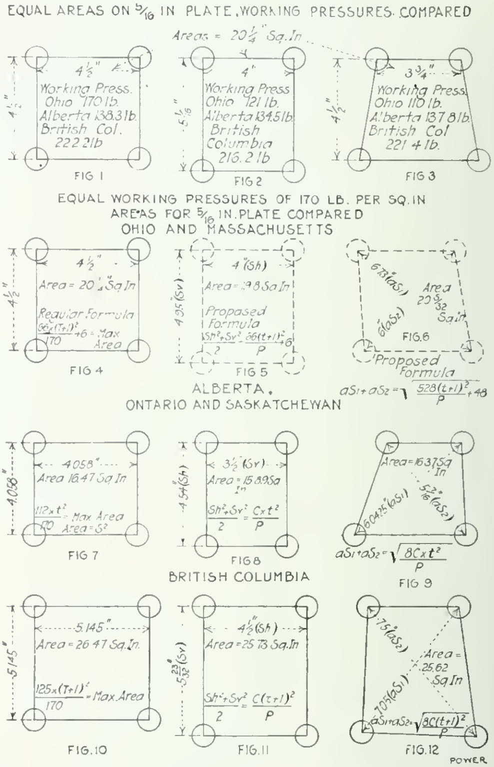

PLATE II. AREAS AND PRESSURES COMPARED*

shown thereon. In Figs. 2 and 3 S, for Ohio must be taken from the greatest distance, which accounts for the low pressures shown thereon. In the lower Figs. 4 to 12, the comparison is made with equal pressures, (170 lb.), the diagrams being each drawn to the same scale and the number of square inches shown thereon, give the comparison of areas as figured by the various rules. Referring to Figs. 5 and 6, Ohio and Massachusetts give no rule for figuring these areas, but we have for Fig. 5 substituted

$$\frac{Sh^2 + Sv^2}{2} \text{ for } S^2$$

in the regular formula

$$S^2 = \frac{C \times (t + 1)^2}{P} + 6$$

the same as allowed in the Canadian rules—then the formula for Fig. 5 becomes

$$\frac{Sh^2 + Sv^2}{2} = \frac{C \times (t + 1)^2}{P} + 6$$

In actual practice one of these dimensions, either Sh or Sv, will be predetermined so that it is only necessary to solve for the other.

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*To agree with the text read dS_1 for aS1, dS_2 for aS2, S_h for Sh and S_v for Sv in this plate.

For Fig. 6, irregular spacing, we have substituted $dS_1 + dS_2)^2$ for S^2 so the formula for this case becomes

$$dS_1 + dS_2 = \sqrt{\frac{8 \times C \times (t + 1)^2}{P}} + 48$$

In practice the sum of the two distances $dS_1 + dS_2$, will usually be used in laying out the staybolts, and it is only necessary to see that the sum of these two distances does not exceed the sum of the diagonals of the square diagram as shown in Fig. 4. If one diagonal is predetermined the other may be calculated easily.

After using the Canadian formulas in laying out several sizes of boilers and making careful comparisons of the pressures allowed by the various rules, it is recommended that these substitutions in place of S^2 for uneven and irregular spacing be allowed in all of the rules.

The distance in inches which the head is considered as supported from the shell and tubes is given in Table 3 for several thicknesses of plate and 170 lb., working pressure.

TABLE 3

Thickness of Plate In.	Distance from Shell Ohio, Mass. In.	Alberta, Ont., Sask. In.	British Columbia In.	Distance from Outside of Tube, Ohio, Mass. In.	Distance from Center of Tube Alberta, Ont. Sask. In.	British Columbia In.
5/16	3	2.02	2.57 + Rad. at flange	2	2 02	2.57
3/8	3	2.41	3 In. + R "	2	2 44	3
7/16	3	2.84	3 42 + R "	2	2.69	3.42
1/2	3	3.24	3.85 + R "	2	3 24	3 85
9/16	3	3.65	4.28 + R "	2	3.65	4.28
5/8	3	4.06	4.71 + R "	2	4 06	4 71
11/16	3	4.46	5.15 + R "	2	4 46	5.15

It will be noticed that the distance allowed by Ohio is the same for any thickness of plate and for all pressures. The Canadian formulas take into consideration the thickness of plate and the pressure so the distance changes with these two terms. Notice also that the British Columbia rules allow the addition of the curve at the flange while none of the other rules take this into account. This curve, no doubt, gives support to the head.

The heads, used on locomotive-type boilers are shown in Plate III; Fig. 1, shows the portion of the rear head which is considered supported by the shell according to the several rules while Fig. 2 shows the similar parts of the tube sheet. The inner crescent-shaped part being the area which is to be supported by stays or braces.

The Ohio rules make no mention of doubling plates, but some provision should be made in all the rules for the added strength obtained by their use, as is done in the Alberta rules, where the thickness of plate in the formula is taken as 75 per cent. of the combined thickness of the two plates, when the doubling plate is securely riveted to the head.

STAYBOLTS, THROUGH STAYS AND DIAGONAL BRACES

The maximum stress per square inch allowed by the various rules is given in the table which follows:

TABLE 4

Kind of Stay and Material	1¼" Dia. and under, Ohio and Mass. Lb.	Over 1¼" Dia., Ohio and Mass. Lb.	Less than 1¼ Sq.In. Net Sect. Area, Alberta, Ont., Sask., Lb.	Over 1¼ Sq.In. Net Sect. Area, Alberta, Ont. and Sask., Lb.	Not Worked in Fire (Any Dia) B.C. Lb.
*Stay bolts, mild steel, weldless	6500	7000	8000	9000	9000
Stay bolts, wrought iron, weldless.	6500	7000	7000	7000	7000
Through stays, steel weldless	8000	9000	8000	9000	9000
Through stays, wrought iron, weldless. .	7000	7500	7000	7000	7000
Diagonal or crowfoot braces, steel, weldless	7500	8000	8000	9000	9000
Diagonal or crowfoot braces, wrought iron, weldless. . . .	6500	7000	7000	7000	7000

*In Ohio and Massachusetts if a certified report of the physical properties of weldless stays or stay bolts is filed with the data report, the maximum allowable stress of such stays may be based on a factor of safety of six and five-tenths (6.5).

In the Canadian provinces the angularity of the diagonal braces must be taken into account when figuring the load on them while in Ohio and Massachusetts there is a reduction made in the maximum stress allowed, which is intended to cover the increase in strain due to this angularity. According to all of the laws under consideration threaded staybolts with riveted ends are approved. For through stays, Ohio and Massachusetts do not specify in the printed rules any regular way of attaching them, but the Board of Boiler Rules in Massachusetts has made the requirement that all through stays shall have nuts on the inside and outside of heads. In the Canadian provinces the through stays must have nuts on the outside and the ends are not allowed to be riveted. If nuts are placed on the inside of the plates a greater constant is allowed in figuring the working pressure on the heads.

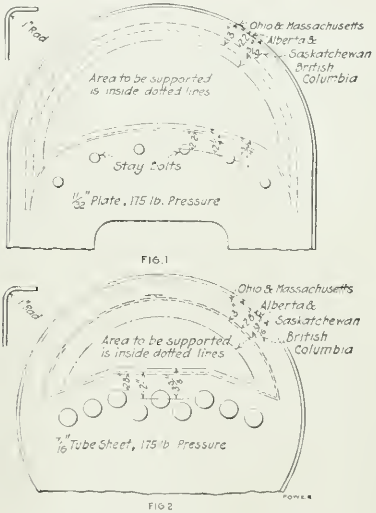

PLATE III. AREA TO BE STAYED

Steel angle and tee bars are not allowed to be used to support the segments of heads on boilers over 36 in. in diameter and carrying a pressure of over 100 lb. per square inch.

HANDHOLES AND OTHER OPENINGS

All of the rules require that in the locomotive type of boiler there shall be at least six handholes located substantially the same.

In addition to the six handholes mentioned the Canadian rules require that there shall be six washout plugs in a boiler or that the total number of handholes and washout plugs combined shall be at least twelve.

The Ohio and Massachusetts rules do not require these washout plugs. It would be, however, advisable on this type of boiler to require a washout hole at or near the waist seam on top of the boiler and another in the front tube sheet above the tubes or in the shell sheet near this tube sheet, omitting the other four required by the Canadian rules.

The Ohio rules require that an opening for a threaded-pipe connection shall not have less than the minimum number of threads, as shown in Table 5.

TABLE

Size of pipe connection in inches....	1 and 1¼	1½ and 2	2½ to 4 inc	4½ to 6 inc.
No. of threads per inch	11½	11½	8	8
Minimum no. of threads required in opening	4	5	7	8
Minimum thickness of material required to give above no of thds.	0.348" (0.375" = ⅜")	0.435" (0.4375" = $\frac{7}{16}$")	0.875"	1"

If the thickness of material in the boiler is not sufficient to give such number of threads, there shall be a standard flange, or steel plate, substantially riveted to the boiler to give the required number of threads.

By the Alberta rules the boiler shall be reinforced with a plate securely riveted to the shell, and threads full size through both plates, and the pipe fitting tightly in both. I consider the rules of Ohio in regard to pipe openings superior since the thickness of the plate determines whether the opening shall be reinforced or not.

STEAM DOMES ON CYLINDRICAL SHELL OF BOILER

The Ohio rules make but little mention regarding domes on a boiler. but do require that when a dome is to be used, there shall be a working drawing of the same submitted to the department of inspection for approval.

The rules of Massachusetts are, in the opinion of the writer, rather absurd when applied to small boilers in view of the fact that no consideration is taken of the factor of safety which the joints figure or the working pressure which is carried, neither is there any consideration taken of the size of the dome.

The writer commends the method of reinforcing the openings in the shell under the dome as required in the Alberta and Saskatchewan rules.

The single-riveted lap seam should be allowed on the flange of a dome when the tensile strength of the rivets has a factor of safety of not less than ten when calculated from the lifting force of the steam acting on the area inclosed by the rivet circle; and on the vertical seam of the domes, the single-riveted lap joint should be allowed when the inside diameter does not exceed 16 in., providing the factor of safety of said joint shall be at least 8 and the double-riveted lap joint be allowed when the diameter is not over 24 in., providing the factor of safety of said joint shall be at least 7.

HYDROSTATIC PRESSURE TEST

The hydrostatic pressure test of one and one-half times the working pressure is required to be made on all boilers which are built or inspected under all of the laws which are being considered.

SAFETY VALVES

Spring loaded safety or pop valves, nearly alike, are required by all of the rules, to be connected to every boiler independent of any other steam outlet; no stop valve being allowed in the connection. In Ohio and Massachusetts these valves must have the stem connected directly to the disk of the valve and be provided with a lifting device so the disk can be lifted from the seat with the spindle, while the rules of the Canadian provinces require a pop valve with a lifting gear provided to ease the valve.

STEAM GAGE

A steam gage and siphon are required on every boiler by all of the rules, and the steam gage shall be attached to the boiler in such a way that the steam cannot be shut off from it except by a stop-cock.

The Ohio rules do not specify the size of water columns to be used, but limit the minimum size of pipe connections to one inch; neither do they require shutoff valves in pipe connections to the boiler. At least three gage-cocks are required on all boilers carrying a pressure of over 25 pounds per square inch.

The Canadian rules require that the internal diameter of the water column shall be 2 and 3 in., respectively, for certain sizes of boilers. Straightway valves or cocks must be placed on the pipes connecting the water column to the boiler and two gage-cocks are required on boilers 30 in. in diameter and under, and three when the diameter exceeds 30 inches.

I consider three gage-cocks are unnecessary on small boilers and the Alberta rule is good in this respect. Putting stop valves in pipe connections to the water column is considered poor practice as these valves may be inadvertently closed and thus be a source of danger. Where these valves have been used they are generally found to be more of an annoyance than a safety device.

From the points that have been mentioned and comparisons that have been made it will be understood to be difficult to manufacture stock boilers that will pass the laws of the various states and provinces.

There is an ever increasing demand for boilers that will be allowed to operate under any of the laws, from purchasers who are doing contract work in various parts of this country as well as in Canada. To meet this demand the manufacturer has often appealed to those in authority for a modification of their rules, but has nearly always found them arbitrary in their decisions and seeming to refuse to approve points of good construction without explaining their objection, simply saying that "the rules do not provide for such construction." For example, Alberta has refused to accept boilers with the double-riveted butt-strap joint, as shown in Plate 1, Fig. 3. Likewise, Massachusetts has arbitrarily ruled against other features of good construction, simply because they were not approved by the Board of Boiler Rules.

There will be, no doubt, a great variance of opinions on many of the points covered, but the writer's intention has been to touch on the points of most importance brought to mind in his efforts to design standard boilers manufactured as stock to be shipped into any commonwealth having boiler laws.

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Permanent Exhibition Planned by New England Commercial Engineers

The New England Association of Commercial Engineers, with headquarters in Boston, has planned a machinery exchange or bourse in this city, where manufacturers and agents handling power-plant equipment and material may secure space to exhibit and demonstrate their goods.

The association is considering three floors in a large mercantile building midway between North and South stations. The floor area is ample for one hundred spaces, some with private offices, and assembly hall, two smaller halls, lounging room, library, committee and consultation rooms. The aim is to give all the possible advantages of a club, with business possibilities. It is proposed to have the halls used by the many engineering societies, making it the engineering headquarters of New England.

In its circular, the association requests those interested to communicate with Herbert E. Stone, 53 Equitable Building, Boston, Mass.

Wisconsin State Convention

On Sept. 6 and 7, the Wisconsin State Convention was held in Milwaukee, at the Republican House. As it preceded the National convention in the same city, many of the delegates were on hand to attend the big event of the year. John A. Wickert, chairman of the local committee, opened the convention on Sunday afternoon. The address of welcome was given by Henry J. Mistele, and A. Gunderson responded, praising Milwaukee as a convention city and thanking the local committee for its good work. He reviewed the work of the past year and offered some valuable suggestions for the improvement of the organization.

National Secretary Raven spoke of the advantages of getting together and of the improvement in state conventions. He referred to the work being done to secure state license and inspection laws and of money to be appropriated for educational work. The secretary made a special appeal for the careful and judicious selection of officers, as the proper kind of men would set an example to their successors, and by their energy and zeal in office insure the success of the organization they represent.

Fred Ruck, vice-president, responded to the secretary. He enlarged upon the benefits which can be derived from the association, and emphasized the fact that the primary object of the association was to carry on educational work and enact state license and inspection laws. He reviewed efforts in the past which had resulted in failure, but reminded the delegates that plants were getting large and the question asked today was not whether a man could keep the plant running, but what were his accomplishments? At what efficiency could he run the plant? This advancement in requirements by the owner will gradually pave the way for the passage of license and inspection laws, as the owner will realize that the laws will be to his advantage in securing a competent engineer.

The meeting was then turned over to President Gunderson, who favored more advertising for the association. Money should be set aside to defray the expense of traveling and correspondence by the state deputy. All engineers in the state should know of the work the organization is doing. A personal visit will often stir up enthusiasm and result in a new local.

Committees were appointed and routine business followed. The secretary reported a gain in membership of from 520 to 542 (a net gain of 22) during the year. The financial conditions, as reported by the treasurer, were flourishing.

At the second and last session, Monday morning, there was considerable discussion on mileage and missionary work to arouse interest in the association, and increase the enthusiasm of some of the locals already organized.

George H. Wallace, of Racine, pointed out that interest in the home organization was necessary for the success of the local, and indirectly the success of the national body. He outlined methods followed at Racine, which had resulted in an average attendance of 65 per cent. of the membership and 98 per cent. on election nights.

Sheboygan was chosen as the convention city for 1915, and the following officers were elected: Fred Ruck, of Milwaukee, president; Charles Bindrich, of Milwaukee, vice-president; Robert Fenn, of Sheboygan, secretary; John Novotny, of Madison, treasurer; G. H. Wallace, of Racine, conductor; A. C. Willert, of Manitowoc, doorkeeper, and Charles Cahill, of Milwaukee, state deputy.

* *

National Convention N. A. S. E. at Milwaukee

From Sept. 7 to 12 the National Association of Stationary Engineers held its thirty-second annual convention at Milwaukee. The biggest and best, was the unanimous verdict of those attending. The exhibits presented an unusually attractive appearance and were greater in number than ever before. The attendance was good and the entertainment gave evidence of a master hand. Little touches here and there and the unusual at the right moment enhanced an excellent program. The chairman of the local committee, and in fact nearly every member of the N. A. S. E. in Milwaukee, were on the job every minute of the convention. That their work was well done every delegate and visitor will agree, and it is safe to say that Milwaukee will long be remembered as the banner convention city. The Auditorium, with its numerous halls and committee rooms, offered every facility for the convention. The exhibits were displayed in the large amphitheater on the main floor, the business sessions were held in an adjoining hall, the grand ball on the floor above and the field day sports on a track in the basement.

Monday, Sept. 7, was given over to the reception of delegates and visiting engineers. John C. Foote and the convention band were in evidence as they met the various delegations and escorted them to the hotels of the city. Delegates registered and badges were distributed. In the evening the mechanical exposition was officially opened, with John A. Wickert, chairman of the local convention committee, presiding. J. P. Keenan, secretary of the Citizens Business League, welcomed the conventioners to the city and wished them every success. He outlined briefly the great industries of the city and invited the delegates to look them over. Homer Whelpley, president of the National Exhibitors' Association, appreciated the efforts of the local committees and was desirous for a large attendance of local engineers. National Vice-President Ray spoke of the value of the exhibits as an educational feature. A careful study of the various appliances would result in a great deal of good, as the latest and best in power-plant equipment could be seen under one roof. President Coe officially opened the exhibition.

OFFICIAL OPENING

Tuesday morning the convention was officially called to order by John A. Wickert, who briefly referred to the efforts made in bringing the convention to Milwaukee. The present gathering was compared to the conventions of 1888 and 1900 held in Milwaukee. Rev. W. T. Dorward offered the invocation and Gov. F. E. McGovern was introduced. In his address of welcome the governor declared that the invention of James Watt in 1769 had benefited civilization more than the accomplishments of Wellington or Napoleon. Watt's genius and the sagacity of his partners marked the beginning of the end of household manufacture and inaugurated the era of steam, which has been responsible for the tremendous development of the industries. The governor spoke of the efforts of the state to secure compensation to the workmen for industrial accidents. He favored state license and inspection laws and offered to coöperate with the association in bringing the matter before the legislature. President Coe made a suitable response and Mayor Bading welcomed the delegates to the city, pointing out its industries, beautiful parks, recreation features and above all the strong yet well balanced spirit of personal liberty which ruled the city. The mayor believed that the licensing of engineers should be a state function and not that of a city. National Vice-President Ray thanked the state and city executives for their cordial welcome, outlined the objects and ideals of the association and concluded with a fitting tribute to Milwaukee.

W. G. Bruce, secretary of the Merchants and Manufacturers' Association, recounted briefly the historic and civic peculiarities of the city. "Efficiency should be the keynote of the organization" were his parting words. It is this factor which has made Milwaukee one of the largest manufacturing centers and in the shadows of Chicago increased her population from a few scattered settlers to a city of 400,000 in the past eighty years.

Past President McGrath linked the convention city with the names of Reynolds and Hollis and spoke of the wonderful transition caused by steam. The work of the association was bearing fruit, and no better proof was needed than the personnel of the audience.

Chairman Wickert presented President Coe with a silver-banded gavel. The latter assumed the chair and after the appointment of the usual committees the session adjourned for the official photograph.

OFFICIAL REPORTS

The afternoon session was devoted to official reports of the national president, secretary, treasurer and license and educational committees. The president reviewed the work of the past year under the headings: Education, License Legislation, "The National Engineer," State Associations and National Calendar, ending with the following seven recommendations:

"First: That the advisory board in conjunction with the

Delegates and Guests at the Thirty-Third National

National educational committee and under the supervision of the president, be allowed to spend a sum not to exceed $2000 for the completion of all slides under way and to present a policy that will demonstrate the true value of such a system, and the other work for the coming year.

Second: That a committee be appointed by the National president to work in conjunction with the local convention committee on a program that will establish a uniform standard of procedure and in this way assist the smaller states to accomplish greater results. Also that a standard badge be adopted for state committees.

Third: That the legislative committee, under the supervision of the National president be allowed a sum not to exceed $2000 for the carrying out of an ambitious policy of license and boiler inspection laws.

Fourth: That an amendment as introduced by No. 1 relating to nonresident members be approved, as this will allow your national officers a greater leeway to increase our membership and revenue.

Fifth: That we do not continue the return dividend to the associations as no indications are apparent that the same has increased our income from our paper, increased the membership or increased the allowance to delegates from the association; and in its place would recommend that $5000 be set aside for propaganda work to be expended in five states selected by the convention or the National president. And for the carrying out of this work a member be selected who has had a broad experience in the details of our organization, and one who will devote all of his time to this and other work as designated by and under the supervision of the National president.

Sixth: That all slides and property of the advisory and educational committees be insured.

Seventh: That the present policy of bonding our funds in bank be continued.

National Deputy and Vice-President Ray reported twelve new associations. Dues to troubles experienced by state deputies with corresponding secretaries of state subordinate associations be recommended a committee of three be appointed to devise a system of keeping suitable records.

Secretary Raven's report was bound in a 24-page booklet covering all details of business transacted, increase of local organizations, list of new associations, etc. The total membership is now 22,118. The report of the National treasurer showed expenditures of nearly $40,000 and a reduction of the treasury balance to $20,000.

The National educational committee gave a full report. Their work followed as closely as possible the suggestions given by last year's committee. In the prize question and answer contest from Jan. 1 to Apr. 1, 44 papers were presented, 25 in the elementary and 19 in the advanced contest. The prizes were awarded as follows:

ADVANCED CONTEST

First, $75—Romeo A. Grise, Connecticut, No. 7.
Second, $50—Martin O'Connor, Wisconsin, No. 1.
Third, $30—Joseph Collins, Massachusetts, No. 17.

ELEMENTARY CONTEST

First, $50—John E. Jamboe, Wisconsin, No. 18.
Second, $30—Harry Swindler, Ohio, No. 50.
Third, $10—Robert R. Frey, Ohio, No. 42.

Following last year's plan, the committee again offered four prizes to associations which held the best meetings from an educational standpoint, the conditions being that the secretary should send a synopsis of the lecture or talk, the number taking part in the discussion, percentage of membership present, etc. Seven associations sent in reports of 24 meetings as compared to two associations and three reports last year. Announcement of rewards was reserved for a later date. The information bureau had answered 75 questions during the last year and a great deal of time and money had been spent in getting up sets of lantern slides for educational purposes. Details as to number and character of the slides were given and recommendations were made for a continuation of the work.

Kentucky and New Jersey were the only states heard from on contemplated legislation. In the former a license bill was defeated and in New Jersey the necessary appropriation for financing the engineers' license department was secured.

Wednesday morning session was given over to routine business, the presentation of other decorations to associations making gains of over 20 and silk flags to those adding more than 10 members. For the former 16 were eligible, Ohio No. 21 leading with a gain of 151. Flags were awarded to 17 associations.

On Thursday the credential committee reported that 411 delegates were in attendance. The mileage was 311,648, and at 5c. a mile would amount to $15,584.40. The trustees of "The National Engineer" reported a total volume of business of $86,470 and a production of revenue for the association of $17,300. A resolution calling on the president to appoint a representative to attend the meeting of the American Society of Mechanical Engineers dealing with the standardization of laws pertaining to the construction and operation of steam boilers was adopted. At the close of the session the annual memorial service was held. During the past year 180 members had passed away.

At the meeting of the Life and Accident Department, James G. Beckerleg, of Chicago, was reëlected chairman of the board of trustees, W. M. Brainerd was elected as a member and J. D. Taylor, of New York City, was reëlected secretary-treasurer at a salary of $1200 per year. The policy holders total about 2200.

On Friday the ways and means committee recommended $2500 for the educational work next year, and $2000 to the license committee for a comprehensive campaign. Both proposals were adopted. The contract for printing "The National Engineer" for a period of five years beginning February, 1915, was reawarded to the Mechanical Press of Chicago.

Officers of the Ladies' Auxiliary were escorted to the platform and welcomed by President Coe. Response was made by President Sophie Whelan. She reported 12 pensioners on the list, each receiving $15 per month. It was her earnest plea that this amount be increased to $20 or even $25 per month. Mrs. Margaret Flynn, secretary, read the financial statement. In September of 1909, the auxiliary had $3975.70, since then $8962.75 had been received and $5589.69 had been paid out. Mrs. Gertrude Hunt, vice-president, gave a brief address and the treasurer, Mrs. Emma M. Stone, told of the great good accomplished by the pension fund. A committee appointed to take up the usual collection for the pension fund received $128.47.

ELECTION RETURNS

Election of officers was the next order of business and resulted as follows: President, Frederick L. Ray, of Louisville, Ky.; vice-president, Walter H. Damon, of Springfield, Mass.; secretary, Fred W. Raven, of Chicago, Ill.; treasurer, Samuel B. Forse, of Pittsburgh, Penn.; trustee of "The National Engineer" for the term of five years, Henry J. Mistele, of Milwaukee, Wis.; conductor, Louis A. Kroner, of Cleveland, Ohio; doorkeeper, J. J. McDonald, of Tacoma, Wash.

Convention of the N. A. S. E., at Milwaukee, Wis., Sept. 7 to 12, 1914

Columbus, Ohio, was chosen as the next convention city.

ENTERTAINMENT

Entertainment features were a visit to the Schlitz Brewing Co., a smoker under the auspices of the exhibitors in Juneau Hall auditorium, a luncheon at Allis-Chalmers Co. and an inspection of the works, band concerts at the exhibition hall, a field day in which all participated, a vaudeville show by the exhibitors, automobile sight-seeing trips and on Friday evening the grand ball and cotillion. This was a grand affair, ably conducted. Over 10,000 favors or souvenirs were given away. A feature was the explosion of a paper boiler resulting in a shower of confetti over the audience. As a prelude the National officers were installed. Dad Beckerleg with the first National president, Henry Cozens, acting as conductor, officiated.

LADIES' AUXILIARY

On Wednesday afternoon the fourteenth annual convention of the National Ladies' Auxiliary convened at the Wisconsin Hotel, with Rose J. Tellier, chairlady of the local convention committee, presiding. Mrs. Teller welcomed the conventioners to Milwaukee and was followed by Rev. W. T Dorward in an eloquent address. Response was made by Ollie L. Heckler, past National president, who spoke of the work of the organization and referred particularly to the pension fund. The treasurer, Mrs. Emma M. Stone, reported a balance on hand of $7338.76. That evening a card party was held at the auditorium and on Friday the following officers were elected: President, Mrs. Gertrude Hunt; vice-president, Mrs. M. Huntington; corresponding secretary, Mrs. Margaret A. Flynn; treasurer, Mrs. Emma M. Stone; conductor, Mrs. Moore; chaplain, Mrs. Minnie Wickert; doorkeeper, Mrs. Lowrie.

THE EXHIBITS

These were arranged in excellent taste and covered a wide range of power plant apparatus. There were 198 booths, 143 individual firms exhibiting and approximately 500 representatives. The display is credited as being the best in the history of the organization. At the annual meeting of the National Exhibitors' Association the following officers were elected: President, Harry A. Pastre of the Elliot Co., Pittsburgh; vice-president, Lane Thompson of the Lunkenheimer Co., Cincinnati; secretary, H. D. Raymond of the A. W. Chesterton Co., Boston; treasurer, J. W. Peterson of the Richardson-Phenix Co., Milwaukee; executive committee, T. C. Green of the Garlock Packing Co., Pittsburgh; P. T. Payne of the Dearborn Chemical Co., Chicago; Charles Cullen of the William Powell Co., Cincinnati; A. R. Foley of the Home Rubber Co., Trenton, N. J.; and C. A. Wilhoft of the New York Belting & Packing Co., New York City.

BOOKS RECEIVED

HEAT ENGINES. By John R. Allen. McGraw-Hill Book Co., New York City. Cloth; 320 pages, 6x9¼ in.; 185 illustrations; tables. Price, $3.

TECHNICAL MECHANICS. By Edward R. Maurer. John Wiley & Sons, Inc., New York. Third edition. Cloth; 356 pages, 6x9½ in.; 91 illustrations. Price, $2.50.

PUMPING BY COMPRESSED AIR. By Edmund M. Ivens. John Wiley & Sons, Inc., New York City. Cloth; 241 pages, 5¾x9¼ in.; 106 illustrations; tables. Price $3.

NEW PUBLICATIONS

FUEL, GASEOUS, LIQUID AND SOLID. By J. H. Coste and E. R. Andrews. Published by J. B. Lippincott Co., Philadelphia, 1914. Size 5x8 in.; 278 pages; illustrated. Price $2

No attempt is made to treat the economic aspect of the various fuels and their uses, as there is abundance of literature upon this subject; instead, the authors have confined their efforts to the production of a reference book of laboratory methods for making analyses and determining the heat values of fuels.

The text is arranged in two parts, the first devoted to the chemical and physical examination of gaseous, liquid and solid fuels, with directions for sampling and analyzing, and the second covers the calorimetry of such fuels. The work of such authorities as the Bureau of Mines, the American Chemical Society, the Royal Society, etc., has been freely quoted, approved apparatus is described, and the opinions of the authors are given as to the methods and appliances likely to yield the most satisfactory results under different conditions.

While not highly technical, in the sense of theoretical and mathematical treatment, the book is not adapted to the amateur, but rather to the needs of one who has had some experience in laboratory methods.

MECHANICS AND HEAT By William Ballantyne Anderson, Ph.D. McGraw-Hill Book Co, Inc., New York and London 6x9 in.; 349 pages; cloth; illustrated. Price, $2.

This is not, as might be inferred from the title, a dissertation upon the mechanical or dynamic theory of heat, but a text book made up from the mimeograph notes used by the author in his work as associate professor of physics at the Iowa State College, treating of elementary mechanics and of heat. The author has conducted the recitations as well as having lectured, and this experience has been of value in revising the notes to meet the difficulties of the student as the teacher has known him.

The book is divided into three sections: Mechanics, Properties of Matter, and Heat, comprising in all 18 chapters. Through it all, the practical application of the principles taught has been emphasized, and the numerous sketches assist the student in fixing the relations of the laws to concrete examples. Every principle treated in the text is brought up, so far as possible, in a problem, so that in working all of the problems a review of practically the entire book is obtained. The treatment is not beyond the student with a very elementary knowledge of algebra and trigonometry, and the book would well serve one following a course of self-instruction in its subject.

PERSONALS

Royal C. Wise, sales-engineer, formerly secretary and half-owner of the Western Pump & Engineering Co., has disposed of that interest, and established headquarters in the Madison Terminal Building, 9 South Clinton St., Chicago, where he will handle pumping machinery, compressors, and accessories.

A. H. Whiteside has been appointed vice-president and general sales manager of the Goulds Manufacturing Co., of Seneca Falls, N. Y., manufacturer of hand, triplex and centrifugal pumps. Mr. Whiteside is well known in the machinery and allied trades. During the past fifteen years he has been connected with the Stirling Boiler Co. as southern manager, with the Westinghouse Electric & Manufacturing Co. as its Baltimore representative and with the Allis-Chalmers Co. as manager of its power and electric department. In the latter capacity he had charge of all the pumping engine and centrifugal pump business.

Mr. Whiteside succeeds W. E. Davis, who has been obliged to give up some of his active duties due to injuries sustained several months ago.

ENGINEERING AFFAIRS

Uniform Boiler Regulations—The "Canadian Manufacturer" reports that during the last week in June and the first week in July, representatives from several of the provinces met in the Parliament Buildings, Toronto, to discuss boiler regulations and arrive, if possible, at a uniform design. At the conference were the following chief boiler inspectors: John Peck, British Columbia; R. M. Blackburn, Saskatchewan, and D. Metcalf, Ontario. P. J. Tobin, inspector of public buildings, Quebec, represented Quebec, while Nova Scotia was represented by W. G. Matthewson.

Manufacturers of boilers are very much interested in the outcome, as the adoption of uniform regulations will mean that boilers inspected and passed upon during construction in one province can be put into operation in any part of the dominion without further inspection.

At present the regulations in Alberta, Saskatchewan and Ontario are the same, while there are none in operation in the other provinces, though some of them have inspection regulations under consideration.

Wentworth Institute, in Boston, Mass., is a school for instructing in the mechanic arts, founded by Arioch Wentworth. It was incorporated in 1904 and opened for instruction, September, 1911. Last May a new main building was completed, nearly doubling the floor space, so that the institute will be better than ever equipped to carry out its aim, which is to increase the average standard of skill and intelligence in all of the trades for which it establishes courses. Among the latter are electrical construction and operation, the steam engine and the operation of power plants, applied electricity and electrical machinery. Quoting from the catalog for 1914-15, relative to the power-plant course:

> This course is intended primarily for stationary engineers who wish to become more competent, and for young men who are preparing to take examinations for engineers' licenses.
>
> The instruction covers in a thorough and practical way the principles underlying the generation and use of steam, boiler-room practice and engine-room practice.
>
> By means of practical talks and lectures, the student is taught the laws of heat, work, energy and power; the meaning of horsepower and the method of calculating the power developed in an engine cylinder; the action of steam in condensing and non-condensing engines; the characteristics of simple, compound and triple-expansion engines; and the influence of different types of valve gears, etc.
>
> Practice is also given in the laboratory and power plant. This includes setting valves, taking indicator cards, calculating horsepower, making pump tests, injector tests and engine tests for steam consumption and efficiency, etc.; also different methods of boiler firing and conducting boiler tests.

Large Egyptian Pumping Plant—One of the largest pumping installations in the world is being built by the Egyptian Government to drain Lake Mareotis, near Alexandria. It will consist of 18 enormous pumps of the Humphrey type. Each pump is 8 ft. 8 in. in diameter, and is capable of delivering 100,000,000 gal. per day through a lift of 20 ft. The maximum internal diameter of the combustion chamber will be 8 ft. 8 in., and its height 14 ft. The water-valve box will be 8 ft. 8 in. in diameter and 7 ft. high, and it will be fitted with 100 valves of the hinge type, specially designed to enable any valve to close upon an obstruction, without throwing undue strain on the hinges.—"Scientific American."

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans have been prepared for a 200-hp. development in Greensboro Vt., costing $20,000. The plant will supply electricity to the neighboring towns. M. L. Sanders, White River Junction, is Engr.-in-Charge.

The Municipal Gas Co., Albany, N. Y., is having plans prepared by Thomas H. Murray, of the New York Edison Co., Irving Pl. and 15th St., New York, for a two-story power house. Alexander Hamilton is Gen. Mgr.

The Municipal Council, Lewiston, Penn., contemplates establishing a municipal electric-light plant in Lewistown. The estimated cost is $79,000.

SOUTHERN STATES

J. H. Peabody and P. R. Fagan, Cameron, W. Va., have made application for a franchise to build an electric-light plant at Cameron.

The Logan County Light & Power Co., Logan, W. Va., will build a new power station. The following equipment will be required, four 500-hp. boilers, two 2500-kw. turbines, pumps and condensers.

An election will be held Oct. 8 by the citizens of Waterboro, S. C., to vote on the proposition of issuing bonds for $15,000, the proceeds of which will be used for the installation of a municipal electric-light plant.

At an election held Aug. 21, the citizens of Fort Meade, Fla., voted to issue bonds for $25,000 the proceeds of which will be used for the construction of a municipal electric-light plant.

The Beattyville Utilities Co., Beattyville, Ky., is in the market for equipment for a lighting plant. A 150-hp. boiler, 100-hp. engine, 100-kw. generator, a 2300-volt alternator and a switchboard will be required. H. S. Van Zan is Pres.

CENTRAL STATES

Plans are being prepared by Briggs & Melson, 669 Rose Bldg., Cleveland, Ohio, for the construction of a power house at Cleveland, for the Cleveland Seating Co. D. A. Grubb, 550 Rose Bldg., is Mgr.

The Pioneer Pole & Shaft Co., Piqua, Ohio, will purchase motors for the electrification of its plant at Louisville, Ky. Walter Gillette is Supt.

The Public Service Commission has granted permission to the Madison Light & Ry. Co., Madison, Ind., to issue $25,000 in bonds for extending and improving its system. New boilers, and engine and generator and extensions to its local lines are included in the improvements.

POWER

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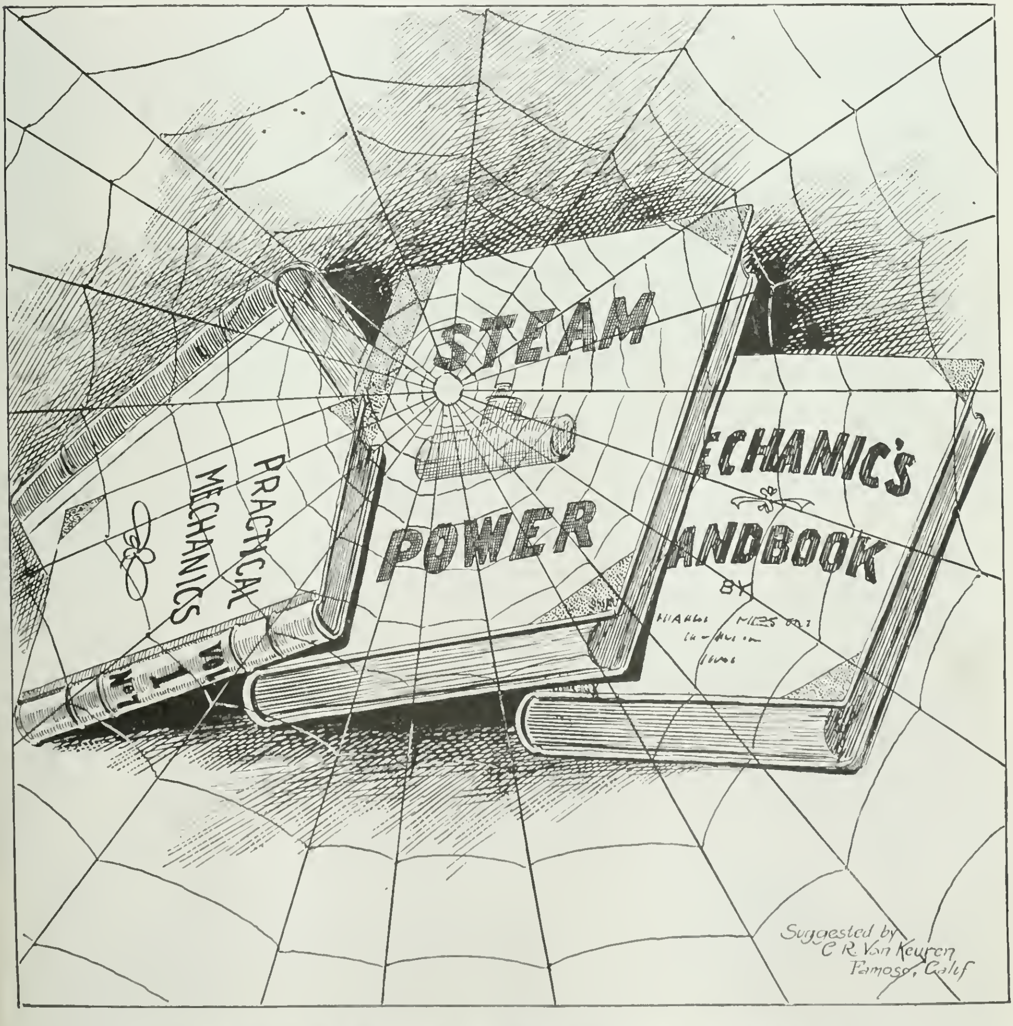


Suggested by
C. R. Van Keuren
Famoso, Calif

DID THIS HAPPEN DURING THE SUMMER?

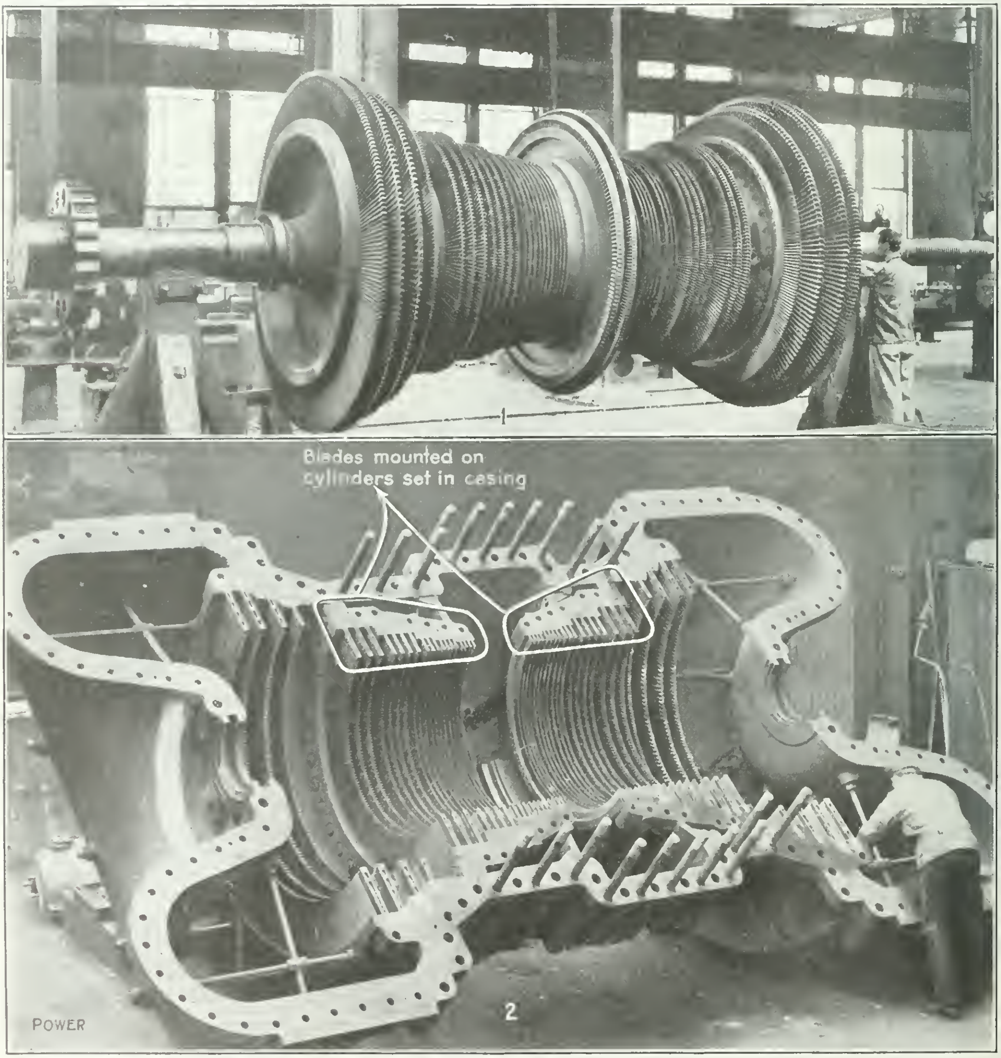
Brooklyn Edison Co's New Turbine

By Charles H. Bromley

SYNOPSIS—The new 22,000-kw. double-flow turbine for the Gold St. station of the Edison Electric Illuminating Co., of Brooklyn, is the largest single-cylinder machine yet built. It is in a space formerly reserved for a 5000-kw. turbo-generating set; the stationary blading is set into cylinders instead of being mounted directly on the casing; straight nickel is used for the high-pressure blading and nickel bronze for the intermediate and low pressure; the condenser has 30,500 sq.ft. of $1\frac{1}{2}$-in. tubes of admiralty composition; the tubing weighs 28 tons, and there is over 17 miles of it. The auxiliaries are guaranteed to consume not more than $4\frac{1}{2}$ per cent. of the amount of steam consumed by the main unit. The intermediate pressure stages will receive the exhaust from the auxiliaries.

*

The Gold St. station of the Edison Electric Illuminating Co., where this new double-flow Westinghouse turbine has been installed, was originally designed for six 5000-kw. turbo-generating sets.



Figs. 1 and 2. The Rotor and Top Half of the 22,000-Kw. Double-Flow Turbine, the Largest Built with a Single Casing

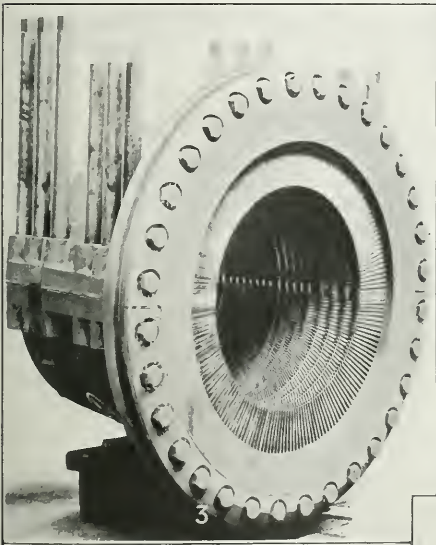
22,000 Kw. in Space for 5000 Kw.

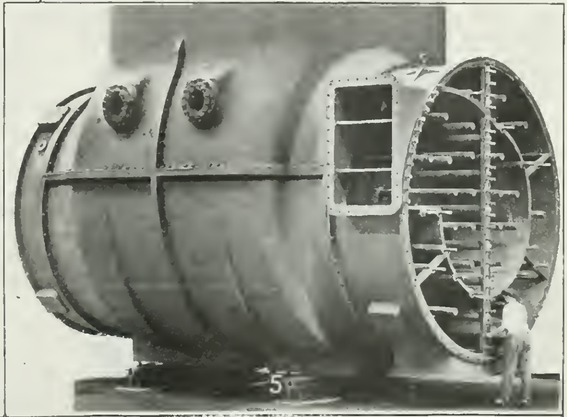
It is noteworthy that the new turbine, of 22,000 kw. rated capacity, is situated on the floor space originally intended for a 5000-kw. machine; over four times the capacity per unit area of floor space. This is a most commendable achievement of turbine designers, considering the real estate values in places occupied by many stations requiring large capacities, although these values are seldom more than 12 per cent. of the cost of the unit. Fig. 1 shows the spindle with blades and Fig. 2 the casing cover.

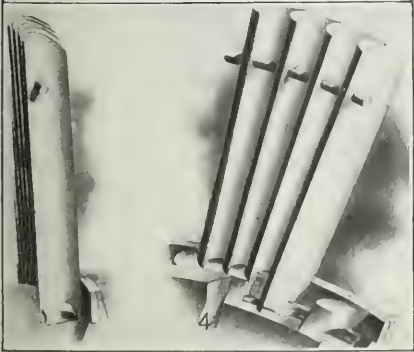
Although rated at 22,000 kw., the set is expected to carry 25,000 kw. for a reasonably long time with a temperature rise of 50 deg. F. The complete set measures 14 ft. 6 in. in length, is 16 ft. 3 in. wide at the base and 12 ft. high. The total weight is 900,000 lb. (450 tons), and the heaviest piece to be lifted by the crane weighs 77,000 lb. At 25,000 kw., the weight per kilowatt is only 36 lb., and 30.43 kw. are accommodated on a square foot of floor space.

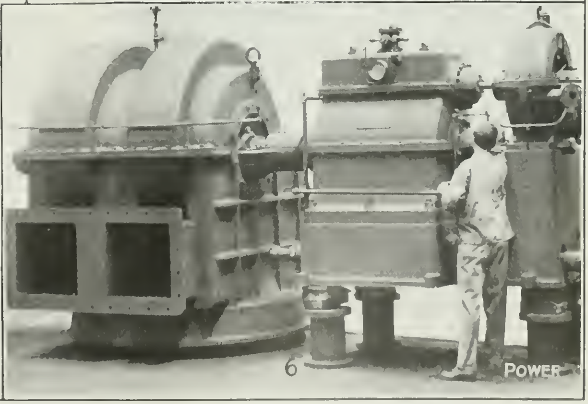
110,583,750 Cu.Ft. of Steam Passed per Hour

The turbine is of the double-flow type, having the usual two exhaust openings, with a total area of 90 sq. ft. At 28½-in. vacuum, equivalent to 0.735 lb. absolute pressure, steam has a volume of 444 cu.ft. per lb., and at the peak load, these exhaust openings will have to pass steam at the rate of 110,583,750 cu.ft. per hr., allowing for the quality after expansion only; the velocity through the openings will be 341.3 ft. per sec. The high- and intermediate-pressure stationary blading will not be fastened directly to the casing, but will be mounted on cylinders set into it. This practice is now being followed by the Westinghouse company for very large units; the 33,000-kw. turbines for the Interborough Rapid Transit Co.'s 74th St. station have this design. The construction gives the casing a more uniform diameter, thereby reducing stresses; it facilitates its manufacture, and it enables the blades and their mountings to be removed or replaced conveniently.









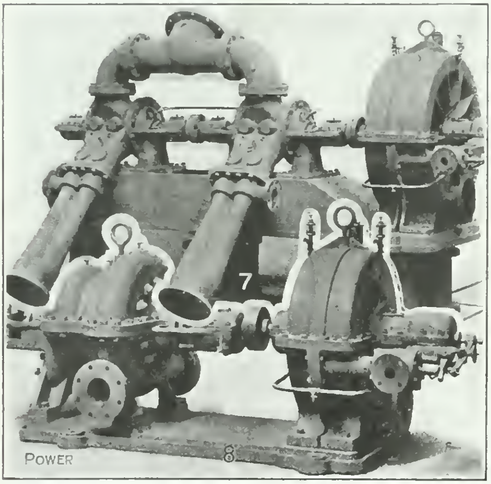
Blades and Some Auxiliaries for the Brooklyn Edison Co.'s New Turbine

Fig. 3. Intermediate pressure blading.
Fig. 4. How the blading is mounted.
Fig. 5. Condenser; 35,000 sq.ft. of 1½-in. tubes.
Fig. 6. 30,000 gal. per min. circulating pump.

Straight-Nickel High-Pressure Blades

Straight-nickel blades will be used for the high-pressure stages, and nickel-bronze for the intermediate- and low-pressure stages. The blades are of greater cross-section at the root or bottom than at the top. This construction tends to reduce, if not to eliminate, vibration; but as the blades are of greater cross-section at the bottom, the stresses to which a blade is subjected are distributed more evenly, so that the root does not bear the greatest stress, as in blades of the ordinary design. The root ends are forged and have about 40 per cent. greater area of cross-section than at the top.

Fig. 4 shows how the blades are assembled. At 22,000 kw., the guarantee calls for a steam rate of 12½ lb. per kw-hr. at 170 lb. pressure, 100 deg. F. superheat, 28½ in. vacuum and 1500 r.p.m. The lowest consumption is at about 17,000 kw. (68 per cent. of the maximum and 77.2 per cent. of the rated capacity), when the curve drops a trifle below 12 lb. per kw.-hr. The generator will furnish three-phase, 25-cycle current at 6600 volts, and has a guaranteed efficiency of 97 per cent., allowing for all losses due to windage, blowers, etc. The usual 2 per cent. speed variation, no load to full load, is allowed. The ordinary type of governor will not be employed, owing to the necessity for avoiding the possibility of trouble due to the governor sticking at times of sudden peaks, for the load on this machine will be constant for long periods.



Figs. 7 and 8. Air and Hot-Well Pumps

The Guaranteed Steam Rate

The steam consumption of the auxiliaries is quite low, being guaranteed to be but 4½ per cent. of that of the main unit. The exhaust from the auxiliaries will be admitted to the intermediate stages of the turbine, through a differential valve which may be set to cut in and out automatically when the load on the main unit varies within predetermined limits, the range depending upon the amount of exhaust steam needed in the feed-water heater to maintain the temperature of the feed.

For the rated capacity of 22,000 kw., the steam consumption is 12.5 lb. per kw.-hr. This means an hourly consumption of 275,000 lb. for the main unit, and, as the auxiliaries need 4.5 per cent. of this amount, or 12,375 lb. per hr., the total hourly consumption will be 287,375 lb. If the boilers are assumed to evaporate 9.5 lb. of water per lb. of coal, then the coal consumption for both the turbine and its auxiliaries is 15.125 tons per hr., or 363 tons every 24 hr. On this basis, 1.375 lb. will be necessary per kw.-hr., not including that required for the 100-hp. motor used for ventilating the generator.

Condensing Equipment

The unit will have a Westinghouse radial-flow condenser, Fig. 5, of 35,000 sq.ft. of tube surface, giving 1.59 sq.ft. of cooling surface per kilowatt. The lowest ratio, so far as the writer knows, is at the Waterside No. 2 station of the New York Edison Co., where a 25,000-sq.ft. condenser serves a 22,000-kw. turbine, giving 1.14 sq.ft. of surface per kilowatt. The condenser will have 45,000 1½-in. tubes, 20 ft. 3 in. long, of No. 16 gage. The shell is 16 ft. 4 in. in diameter and 27 ft. long. The tubing, of admiralty composition, weighs 28 tons, and there are about 17 miles of it.

Tubes for this plant are bought on a guarantee for one year, replacements being made by the manufacturers for those becoming defective within that time. The Gold St. station is immediately alongside the outlet of a 17-ft. sewer and the condensing water is severe on condenser tubes. Tubes of this size are unusual, but as a smaller condenser with 1½-in tubes in the 66th St. station of the Brooklyn Edison Co. has given four years' service without having a cent spent on it except for cleaning, it was deemed best to use the same size tubes for the new unit; then, too, it is a question whether a year's guarantee would be given with 1-in. tubes.

Two 30,000-gal. per min. Westinghouse turbine-driven centrifugal pumps, Fig. 6, driven through Westinghouse-Melville reduction gear, ratio 10 to 1, will furnish the cooling water. Each turbine is of 235 hp. and will run at 2500 r.p.m., giving the pump a speed of 250. The circulating water-pumping capacity per hour per kilowatt rated capacity is 163 gal. For the rated capacity of 22,000 kw. and the guaranteed steam consumption of 12.5 lb. per kw.-hr., the circulating water-pumping capacity gives 108.7 lb. of cooling water per pound of steam condensed. It is expected that during the winter but one pump will be run, owing to the circulating water being cold. The main circulating water discharge into the condenser is 36 in. in diameter and the outlet is 48 in.

The Auxiliary Power

A Westinghouse-LeBlanc air pump, Fig. 7, driven by an 85-hp. turbine and two two-stage wet vacuum or hot-well pumps, Fig. 8, each having a 70-hp. turbine, will be used. These pumps were built to pump against 100 lb. pressure, owing to pipe friction. The total horsepower of the auxiliary turbines is 695, therefore with an over-all efficiency of 90 per cent. for the turbine and generator, the ratio of main-unit to auxiliary power is 38 to 1, figured on the normal rating of 22,000 kw. As the water velocity through the tubes will be low, the bell ferrule will not be employed, as but little erosion of the ferrules is expected.

With cooling water at 60 deg. F., a vacuum of 28.9 in. is guaranteed, and 28.6 in. for 70-deg. water.

Cooled and Moistened Air for the Generator

In large power-plant practice especially, much attention is being given to the ventilation of generators, for the time which the set will carry maximum capacity is limited chiefly by the temperature rise in the generator.

The Brooklyn machine will be ventilated by moistened and cooled air. Briefly, the plan is to maintain a pool of water in the bottom of the fan casing, the distance between the fan and the water being such that when the fan is in motion, enough water will be picked up to moisten and cool the air. As the air enters the delivery side of the duct, it passes between a number of corrugated copper plates which take out entrained water. It is expected that the set will be able to carry from 12 to 15 per cent. more load when fitted with this ventilator than if it had the usual equipment.

Station designers would do well to take advantage of this principle of generator ventilation, for in new plants the heated air leaving the generators might just as well be supplied to the boiler furnaces, and by a suitable arrangement of ducts, heated air from over the boilers might easily be induced into branch ducts joining the main duct, thus increasing the boiler economy, besides cooling the generator at little additional initial investment.

* * *

Legal Rights Concerning Dams

By A. L. H. Street

SYNOPSIS—Authority to maintain structure may be acquired by legislative or private grant, or by long continued enjoyment. Application to public authorities often required by statute, notwithstanding private conveyance of right. Obligations of proprietor to upper and lower riparian land owners. Privileges which may and which may not be exercised. Remedies against improper maintenance.

* * *

The maintenance of dams for power purposes has afforded the basis of much litigation, as is evidenced by the reports of the state and federal appellate courts, with a result that the legal principles applicable to such structures have become fairly well settled. To give the readers of Power a general view of the most important of these principles, so far as they may prove to be of practical interest, the writer has prepared the following summary of the law on this subject, as announced by the highest courts of the country. Citations showing where the full text of some of the leading decisions can be found are given, though the list of citations does not purport to be exhaustive. The observations here made are limited to questions bearing on the right to occupy the channel of a stream with a dam, to detain water from lower riparian owners, and to flow the lands of upper proprietors, leaving out of consideration questions relating to the right to appropriate the waters of a stream —a subject which the writer hopes to be able to cover in a later article in Power.

How Right May Be Acquired

The legal right to erect and maintain a dam may be acquired in any one of the following ways: (1) By virtue of ownership of the land on which it is constructed, (2) by grant from public authorities, (3) by deed from private land owners, and (4) by long assertion of right.

1. In the absence of statutory provision to the contrary, an owner of land along a non-navigable stream is entitled to erect a dam on his own land, without regard to upper and lower riparian owners, if he does not prejudice the lower owners by appreciably diminishing the quantity of water which would naturally flow through their lands, and subject to liability to upper owners for overflowing their lands (California Supreme Court, 69 Pacific Reporter 618; Texas Court of Civil Appeals, 40 Southwestern Reporter 1031). As held by the Massachusetts Supreme Judicial Court, the right to create water power by damming a stream is inseparably connected with ownership of the land through which it flows and does not depend upon acquisition by deed or prescription of rights in land abutting the stream below the dam (88 Northeastern Reporter 332). But in Kentucky it has been held by the Court of Appeals that no one can lawfully erect a dam in a watercourse without first obtaining leave from the court in the manner prescribed by statute (5 Southwestern Reporter 49). And in several other states there are in force laws commonly known as the Mill Dam Acts which require one who desires to erect a dam to apply to public authorities for permission, which is to be granted or withheld on consideration of the public health, as well as the rights of upper and lower riparian owners. Provision is usually made in these laws for the assessment and collection of damages to private property caused by the construction of the dam. Similar procedure is prescribed to acquire the right to increase the height of an existing dam. The statutes of Missouri entitle one who is injured by the construction of a dam, without permission having been first obtained from the county court, to recover double the amount of his damages, and it is likely that similar provisions are in force in other states.

2. The legislature of a state has power to authorize the construction of a dam across a non-navigable stream (United States Supreme Court, 26 Supreme Court Reporter 127; 123 Federal Reporter 707). As a general rule, statutory permission is necessary to authorize the erection of a dam across a navigable river, although it has been held that a riparian owner is entitled to place a dam in the stream if the character of navigation is not such that the dam will constitute a substantial interference (Minnesota Supreme Court, 77 Northwestern Reporter 41; Oregon Supreme Court, 60 Pacific Reporter 384). So far as Congress has not legislated upon the subject, a state may authorize the construction of a dam across a navigable river lying wholly within the limits of the state, for the improvement of navigation, or any other public purpose (United States Supreme Court, 2 Peters 245; 95 United States Reports 459). Legislative permission to construct a dam does not, however, exempt the owner from liability for resulting injury to the private property of others (57 Maine Supreme Judicial Court Report 181; 44 New Hampshire Supreme Court Reports 105). Under United States Revised Statutes, sections 2339, 2340, acquisition of right by prior occupancy to

maintain a dam on public lands has been frequently recognized by the courts.

3. Right to maintain a dam on another's land constitutes such interest in the land that it can be conveyed only by deed or by reservation in a deed (New York Supreme Court, 58 New York Supplement 239; North Carolina Supreme Court, 20 Southeastern Reporter 725). Grant of such privilege is irrevocable by the grantor and operates to relinquish any claim by him on account of damage resulting to his remaining land in the proper exercise of the right (21 Massachusetts Supreme Judicial Court Reports 365). The fact that a dam owner has maintained a 7-ft. head of water only for many years does not prevent him from afterward maintaining an 8-ft. head as against one who granted the right to maintain the greater head. Grant of right to maintain a *head* of water at a certain height does not authorize maintenance of a *dam* at that height, if water flows over the crest at a depth of two or more inches (Michigan Supreme Court, 138 Northwestern Reporter 1073).

4. Maintenance of a dam in a particular manner for many years confers a prescriptive right upon the owner to continue it (116 Illinois Appellate Court Reports 1). A "prescriptive right" is one which the possessor acquires by reason of its continued enjoyment for so long a time as to render it inequitable to deny its existence. But it has been decided by the courts that, by maintaining a dam for 20 years, the owner did not acquire such right as precluded the state from compelling the erection of fishways; and, as decided by the Illinois Supreme Court, a prescriptive right to flood the lands of an upper riparian owner can arise only where the land has been flooded for a period of 20 years or more, and where the flowing was adverse and uninterrupted and took place with the knowledge and acquiescence of the land owner affected (78 Northeastern Reporter 42). This rule is probably applicable in all the states, subject to different holdings as to the length of time the adverse use must continue. The right has been held to be subject to acquisition in Michigan on 15 years' use. But in a recent New York case it was held that judgment in favor of a land owner for six cents damages through maintenance of a dam which flooded his land prevented the power company which maintained the structure from obtaining any prescriptive right of flowage (New York Supreme Court, 136 New York Supplement 383). And it was lately decided that a company which obtained a prescriptive right to maintain a power dam could be enjoined by upper land owners from raising the dam to their injury, although denial of permission to increase the height results in disproportionate injury to the company (Michigan Supreme Court, 141 Northwestern Reporter 693). But the fact that water is set back upon upper land by mere repair of a dam so as to make it tight does not give the upper owners a cause of action, if the dam is no higher than that which the owner has been granted the right to maintain (Illinois Supreme Court, 87 Northeastern Reporter 962). If a dam is so constructed and maintained as to constitute a public nuisance, right to continue its maintenance cannot be acquired by prescription. But when a right has been once obtained by prescription, it will be as fully protected by the courts as though it had been expressly granted by the persons against whom it is asserted (4 New Jersey Equity Reports 116). An owner of land, who by lapse of time has lost the right to object to a dam used in the operation of a mill, cannot enjoin its continuation to provide power for an electric-light plant, unless the change operates to his prejudice by a greater obstruction of the flow of the stream (Kansas Supreme Court, 102 Pacific Reporter 783). But where the right to flood land is acquired by adverse user the owner of the land acquires a reciprocal right to have the water maintained at the same ordinary height (Texas Court of Civil Appeals, 138 Southwestern Reporter 150; Vermont Supreme Court, 77 Atlantic Reporter 866). These principles applicable to the maintenance of dams proper are equally applicable to the maintenance of flashboards (Massachusetts Supreme Judicial Court, 58 Northeastern Reporter 181).

Although the owner of a dam is entitled to detain the waters of the stream so far as is reasonable in his proper use of them, he is not entitled to divert water or to unnecessarily cause loss thereof to lower owners by absorption or evaporation (United States Supreme Court, 4 Mason 397; 1 Hun (N. Y.) 272). When the height at which a dam is permitted to be constructed is determined with reference to "low-water mark," the height of the water at ordinary stages of low water, and not at the lowest stage in seasons of great drouth, governs (Kentucky Court of Appeals, 65 Southwestern Reporter 156).

Right to maintain a dam may be lost by a showing of clear intention to abandon the privilege, but the mere fact that the dam is permitted to decay and remain unrepaired for several years does not establish abandonment of right to renew the structure, in the absence of other evidence of intent to abandon the right (New York Supreme Court, 77 New York Supplement 282). There are earlier cases in other states, however, holding that license to maintain a dam expires with its decay (24 New Hampshire Supreme Court Reports 364; Pennsylvania Supreme Court, 17 American Decisions 677). Right to flood land by water from a dam is not extinguished by a change in the dam's location, if the area flooded is not thereby increased (Rhode Island Supreme Court, 41 Atlantic Reporter 564).

Maintenance of a dam in an unauthorized manner may be enjoined and damages awarded to cover injury already done. A dam maintained in a navigable stream in violation of law constitutes a public nuisance which may be abated on suit (72 Maine Supreme Judicial Court Reports 181); and the owner may be held liable for injury resulting therefrom to private property owners. But all damages claimed by a permanent overflow must be recovered in one suit; where a dam causes occasional recurrent overflows, each overflow affords a separate cause of action in favor of an injured land owner. The damages recoverable for permanent injury to land are measurable by the reasonable value of the land permanently overflowed and the diminished value of the remainder of the tract. If the injury is not permanent, the measure of recovery is the reasonable cost of restoring the premises, plus the difference in their rental value with and without the overflow during the continuance thereof (Alabama Supreme Court, 61 Southern Reporter 934).

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The Production of Coal in Iowa in 1913 was 7,490,641 short tons, valued at $13,431,061, according to figures compiled by E. W. Parker, of the United States Geological Survey, in coöperation with the Iowa Geological Survey. This was an increase over 1912 of 201,112 tons in quantity, and of $278,973 in value.

Inexpensive Flue-Gas Analyzing Outfit

By G. M. Kohler

SYNOPSIS—Directions for the use and manipulation of an outfit which can be bought for less than $5. An analysis can be made in less than five minutes with fairly accurate results.

⁂

In recent issues of Power, considerable space has been allotted to the descriptions of apparatus and methods for analyzing flue gases. All of the outfits mentioned cost more than $25. Many engineers, especially those in charge of small plants and young men just starting in the profession, cannot afford to purchase such costly instruments. The entire outfit described below can be bought for less than $5, it will give fairly accurate analyses and will be helpful to the engineer who desires to learn more about combustion of fuels and efficient boiler operation.

The principal part of the apparatus is the glass tube *H*, in Fig. 1, known to chemists as a "Bunte" gas burette. It is about 1 in. in diameter and 20 in. long. The upper end has a funnel *F*, connected to the main part of the tube by the special three-way cock *C*. The lower end of the tube has a plain stop-cock *D*. The volume of the burette between the stop-cock *D* and the three-way cock *C* is about 115 c.c. A volume of 100 c.c. below stop-cock *C* is graduated to read in ½ c.c., which is ½ of 1 per cent. of the total volume above the zero mark. For convenience in manipulation the burette is attached, by means of the clamps *A*, to the iron stand *S*. A small vacuum pump or aspirator, made of standard pipe fittings, as shown in Fig. 2, is used to draw the flue gases from the furnace or flue to the burette. The gas to be analyzed can also be placed in the burette by means of a pair of bottles, as recently described in Power for the "Orsat."

In addition to the apparatus shown, there will be needed to make an analysis of flue gases, the proper absorbing liquids, viz.; a solution of potassium hydroxide for the absorption of CO_2, an acid solution of cuprous chloride for CO and a mixture of pyrogallic and potassium hydroxide for the absorption of oxygen. Directions for the preparation of these solutions have been given in recent issues of Power.

To fill the burette with a sample of the flue gases to be analyzed, connect the end *E* of the three-way cock *C*, by means of a rubber tube of about $\frac{3}{16}$ in. inside diameter, to the end of a ⅛- or ¼-in. pipe leading to the boiler setting of the furnace from which the gas is to be taken. Connect the nozzle *N* of the burette to the rubber tube *B*, Fig. 2. Now by properly adjusting cocks *C* and *D*, there will be a direct communication from the aspirator to the flue gases within the furnace, so that when water is allowed to flow through the aspirator, the flue gases will be drawn into the burette. The funnel *F* should be filled with water up to the 25-c.c. mark and must be at this level when all readings are made. The gas should be drawn through the burette until all the air in the pipes has been expelled and a fair sample of gas obtained: then shut cocks *C* and *D*, remove the tubes from *N* and *E* and place a cork or piece of tubing with one end closed over *E* to prevent water leaking out of funnel *F*.

In the burette, there is now about 115 c.c. of gas under a slight vacuum. To simplify the analysis the volume of gas in the burette is reduced to 100 c.c. by forcing water into the burette up to and a little above the zero mark. To do this the tube *A*, of Fig. 2, is connected to the nozzle *N* and water is allowed to enter the burette. Great care must be exercised in order that no air enter the burette. The water must be flowing from the tube *A* before it is slipped over the nozzle *N* and the cock *D* must not be opened until the tube is attached. When the tube is removed the water in the burette can be drained off to the zero mark by cautiously opening cock *D*, after which cock *C* should be opened gently, so as to allow sufficient gas to escape through the water in funnel *F*, to reduce the pressure in the burette to that of the atmosphere plus that due to the column of water in the funnel *F*.

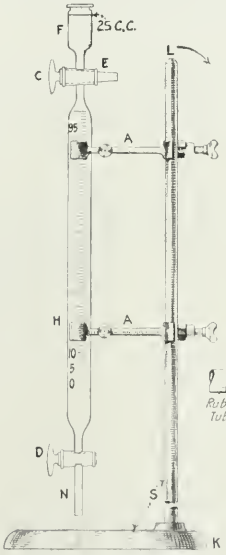

Fig. 1. Bunte Gas Burette

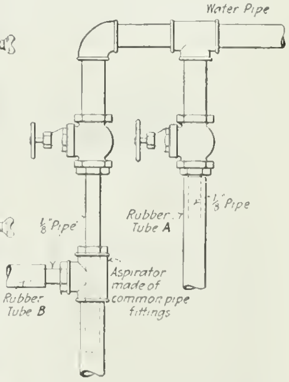

Fig. 2. Aspirator Made of Common Pipe Fittings

The burette now contains 100 c.c. of flue gas, composed of a mixture of nitrogen (N), carbon dioxide (CO_2), carbon monoxide (C) and oxygen (O). In order to ascertain the volume of each of these separate gases, it is necessary to place within the burette some liquid which will absorb one of the gases present. For the absorption of CO_2, a solution of potassium hydroxide is used. The tube *B* is connected to *N*, and water allowed to flow through the aspirator, thus producing a slight vacuum in the tube *B*, so that by opening cock *D* the water in the burette can be lowered until it just covers the cock. The cock should then be closed and the rubber tube removed. A slight vacuum now exists in the burette and by placing a cup containing the absorbing solution, so that the end

N of the burette is dipped under the surface of the liquid, and opening cock D, the absorbing liquid will rise in the burette to almost the zero point, after which cock D is closed.

To bring the gas in contact with the absorbing liquid, and hasten the analysis, the stand and burette can be swayed back and forth about the edge K in the direction of the arrow, by placing one hand at L. After doing this a dozen times the cup containing the absorbing liquid is again held under the end of the burette and cock D opened. If no liquid enters the tube the absorption is complete.

See that funnel F is now filled with water to the 25-c.c. mark, and open cock C so that water can flow into the burette, at the same time adding sufficient water to maintain the proper level in F. When no more water will enter the burette, close the cock.

Now the volume of liquid contained in the burette above the zero mark can be read off and it will be equal to the volume of CO_2 gas contained in the original sample of 100 c.c., or in other words it will be the percentage by volume of the CO_2 present in the flue gas.

To continue the analysis and find the amount of CO present, first wash out the burette by opening cocks D and C, so as to allow water to flow through it, taking care that there is always water above both of these cocks to prevent loss of gas. When a pint or so of water has been passed through the burette, cocks D and C are closed. The water in the burette should stand at the same level as the absorbing liquid did when the reading for the percentage of CO_2 was taken. From this point on the method of analysis for CO is the same as described above for CO_2. The aspirator is used to form a vacuum in the burette and then a cup containing a solution of cuprous chloride is placed under the nozzle N and cock D opened, whereupon the liquid is drawn from the cup into the burette. The apparatus is swayed back and forth several times and more solution put in the burette, after which cock C is opened for a second or two to allow sufficient water to enter the burette to overcome any slight vacuum existing therein. The height of the liquid can then be read off, which, after deducting the former reading for the CO_2, gives the percentage of CO contained in the original sample of flue gas.

To analyze for oxygen the same method of procedure as described for CO is to be followed with the exception of the difference in the absorbing solution to be used.

The description of the method for analyzing flue gases with the above instrument, requires more time than the actual analysis itself. It is an easy matter to make a complete analysis in less than five minutes. The operation is simple when once understood and the outfit will give satisfaction in the hands of anyone who will handle it with reasonable care.

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Motors, Their Principles and Uses--II

By Gordon Fox

SYNOPSIS—Direct-current motors are discussed as to their principles of operation, their classification, characteristics and speed control.

⁂

The frame of a direct-current motor consists essentially of a stationary outer magnetic ring or yoke to which is attached two or more polepieces projecting radially inward. The yoke is commonly made of cast iron or cast steel and the polepieces are bolted to or cast into its inner circumference. Around the polepieces are wound the magnetizing coils of copper wire, and upon the shaft is mounted a cylinder composed ordinarily of sheet-steel punchings. These are punched out in such a way as to present on the surface of the cylinder a series of slots parallel with the shaft; in these slots are arranged the armature coils, the whole rotating element being called the armature. The ends of the coils are connected to the commutator mounted in front of the drum on the shaft and rotating with it. Brushes bear upon the commutator and to these the armature terminals of the motor are connected. The action of the current in the armature conductors upon the magnetic field through the drum results in a turning effort which rotates the drum.*

The action of a direct-current motor is as follows: The armature is subjected to approximately the full line voltage, as its terminals are commonly connected to the two line wires when in operation. The electrical resistance of the armature circuit is small. Current passing through the armature conductors reacts upon the field magnetism to set the armature into rotation. As soon as the armature begins to rotate, its conductors begin to cut the magnetic lines of force emanating from the field poles, and this action, following the laws of the electric generator, sets up in the armature conductors an electromotive force in opposition to the voltage of the external circuit. As the motor increases its speed, this counter electromotive force increases in value, but it cannot quite equal the impressed voltage. The motor attains such a speed that the counter voltage is less than the impressed by an amount such that the voltage difference is just sufficient to force through the resistance of the armature circuit a current sufficient to react upon the field magnetism and produce a torque equal to the mechanical couple demanded by the external load. If the load increases the motor decreases its speed slightly, the counter electromotive force decreases and the voltage difference increases. An increased current is thus forced through the armature, producing sufficient torque to carry the increased load. The characteristic performance of all types of direct-current motors can most readily be understood if these facts are constantly borne in mind.

It will be seen that the speed of a motor depends upon the relation of the impressed voltage to the counter voltage. The latter is proportional to the number of conductors connected in series in the armature and the intensity of the field magnetism. If two armatures were operated in the same field frame, one built with twice as many turns in series as the other, then the first would rotate at half the speed of the second. If a motor be operated at a given speed with the field magnetism at a given intensity and the intensity be decreased, then the motor will increase its speed. This is evident for it will be necessary for the armature conductors to pass the poles more rapidly in order to cut the same number of magnetic lines in a given time and maintain approximately the same counter voltage. The various speed characteristics obtained with direct-current motors all depend fundamentally upon the relations of speed to counter voltage and counter voltage to field magnetism.

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*See Part 1, page 420, Sept. 22 issue.

Direct-current motors are ordinarily classified as being shunt wound, series wound or compound wound. This classification is based upon the method of connecting the field-magnet coils. It will be remembered that the speed and torque characteristics are directly dependent upon the field intensity. If this intensity is made to vary in different ways the characteristics of the motor are controlled in a corresponding degree. The three types of direct-current motor will be considered separately.

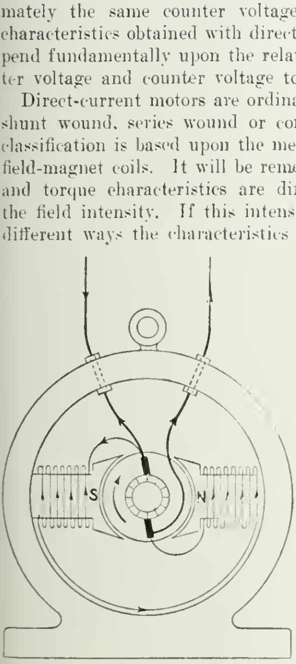

Fig. 1. Shunt Motor

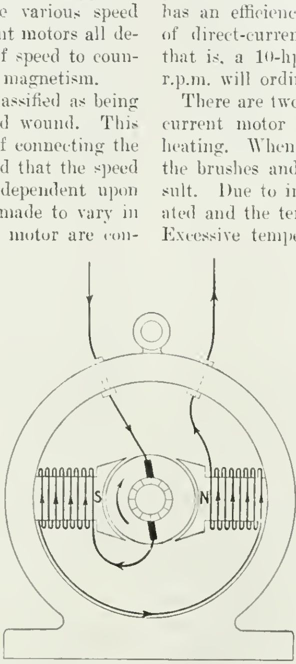

Fig. 2. Series Motor

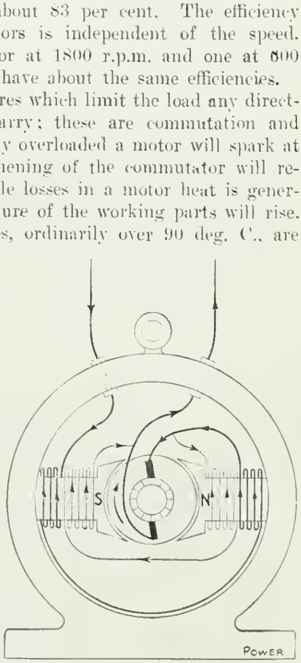

Fig. 3. Compound-Wound Motor

Shunt-Wound Motors

In a simple shunt-wound motor the terminals of the field circuit are connected directly across the line. The field is thus subjected to the full line voltage and the field intensity will remain approximately constant regardless of the load upon the machine and the current in the armature. This motor, then, is essentially a constant-speed machine, although actually the speed does decrease from three to five per cent. from no load to full load. The speed is also affected by the temperature of the field coils and is higher when they are hot, due to the increased resistance of the coils which reduces the field current. The speed can be changed slightly by shifting the brush position on the commutator, but the commutation is affected if the brushes are not correctly located. Fig. 1 shows diagrammatically the connections of a simple two-pole shunt-wound motor, and Fig. 4 gives the characteristics of a typical shunt-wound motor. It will be noted that the speed decreases slightly with an increase in load, that the efficiency is high over a considerable range of load, and that the torque is almost directly proportional to the armature current.

It is consistent with practically all electrical machinery that the larger units show slightly better performance than the smaller ones. For instance, a 5-hp. motor has a full-load efficiency of about 85 per cent., whereas a 100-hp. motor will, at full load, have an efficiency of 90 per cent. or higher. As a general rule, motors show their best efficiency when fully loaded. For instance, a 5-hp. motor, carrying a 5-hp. load, has an efficiency of 85 per cent., whereas a 10-hp. motor carrying a 5-hp. load has an efficiency of about 83 per cent. The efficiency of direct-current motors is independent of the speed, that is, a 10-hp. motor at 1800 r.p.m. and one at 600 r.p.m. will ordinarily have about the same efficiencies.

There are two features which limit the load any direct-current motor will carry; these are commutation and heating. When heavily overloaded a motor will spark at the brushes and roughening of the commutator will result. Due to inevitable losses in a motor heat is generated and the temperature of the working parts will rise. Excessive temperatures, ordinarily over 90 deg. C., are detrimental to the insulation of the coils. Standard horsepower ratings are based upon a rise of 40 deg. C. above the surrounding air. It is evident that increased load involves increased losses. It will carry overloads for short periods, the duration varying inversely with the amount of overload. A good motor will carry 100 per cent. overload momentarily without injurious sparking.

The shunt-wound motor finds a wide field of application in industrial service, since a large and varied class of machines require constant-speed motors with characteristics such as are possessed by the shunt motor. This motor is also commonly used for group and line-shaft drives.

Series Motor

The series motor, as its name implies, has its field circuit connected in series with the armature, as shown in Fig. 2. The wire in the field coils is necessarily large in order to carry the total load current, whereas in the shunt-wound motor the field coils are made up of a large number of turns of small wire carrying a current perhaps one-fiftieth of the value of the armature current. The characteristics of the series motor differ radically from those of the shunt motor. The field being connected in series with the armature, its strength is proportional to the load on the motor. Thus, as load is added the field current increases and the field magnetism grows more intense: this acts to reduce the rotative speed. The series motor runs very slowly under heavy loads and the speed increases rapidly as the load is decreased. If the load be entirely removed, the current is so small that the field magnetism is almost nil and the armature must rotate at an enormous speed to maintain its counter electromotive force. Therefore, series motors are said to "run away" on no load and they are seldom used where it is possible for the load to be entirely removed.

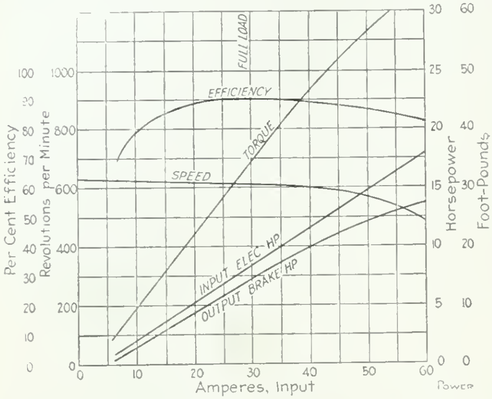

Fig. 4. Characteristics of Shunt Motor

An increase in current in a series motor not only increases the torque directly, but also by strengthening the field magnetism: therefore, the torque of this motor is extremely high under heavy loads where the heavy current operates the iron far above the saturation point. The standstill torque of a series motor may be several times the full-load torque. Fig. 5 illustrates the characteristics of a typical series motor designed for crane and hoisting service.

The efficiencies of series motors depend largely upon the ratings, which, in turn, are based upon temperature rises, but as they are commonly used for intermittent service the ratings ordinarily specify rises of from 40 to 55 or even 70 deg. C. for short periods of full-load operation. In intermittent service it is figured that during the periods of rest much of the heat generated during periods of action will be radiated. The rating used depends largely upon the percentage of the time that the motors are in use.

Series motors are used almost exclusively in traction service and for cranes, hoists, winches, presses and many classes of service where heavy torques at low speeds and excessive starting torques are required. Although in most cases the service is intermittent, they find many applications for continuous service.

Compound-Wound Motors

Compound-wound motors are a combination of the series- and the shunt-wound types, there being two entirely separate sets of coils upon the field poles. One set consisting of many turns of fine wire is connected across the line as in a shunt motor. The other set, consisting of a few turns of coarse wire, is connected in series with the armature. If the shunt and series coils act in the same direction, the motor is said to be cumulatively compound wound; if they act in opposition, it is differentially compound wound. Fig. 3 illustrates diagrammatically the connections of a cumulatively compound-wound motor.

The magnetizing effect of a coil of wire is measured by the number of ampere-turns, that is, the product of the current in amperes by the number of complete turns of wire. Thus the shunt coil having a small current flowing through a large number of turns may have a magnetizing effect comparable with the series coil, which has a heavy current flowing through a few turns. The ratio of series to shunt ampere-turns may, of course, be varied between any limits. Some motors are built with only about 10 per cent. shunt ampere-turns to prevent the motor from running too fast on light loads; others are built with as low as 5 per cent. series ampere-turns. Ordinarily about 20 per cent. of the ampere-turns at full load are in the series coils and the motors are said to have 20 per cent. compounding.

The characteristics of compound-wound motors combine in varying degrees the features of shunt and series motors. Thus cumulatively compound-wound motors, which are much the more common type, have speeds which decrease with an increase of load and torques which increase rapidly with an increase of load. Fig. 6 illustrates the characteristics of a typical 20 per cent. compounded motor.

In a differentially compound-wound motor the field intensity is weakened as the load increases, since the series coils are in opposition to the shunt coils. Thus the speed increases with an addition of load. In some cases this gain in speed will increase the load, which in turn will again raise the speed until a point is reached, such that the series turns predominate over the shunt turns. The motor will then suddenly stop and reverse rotation. Due to its unstable and undesirable characteristics, this type is little used.

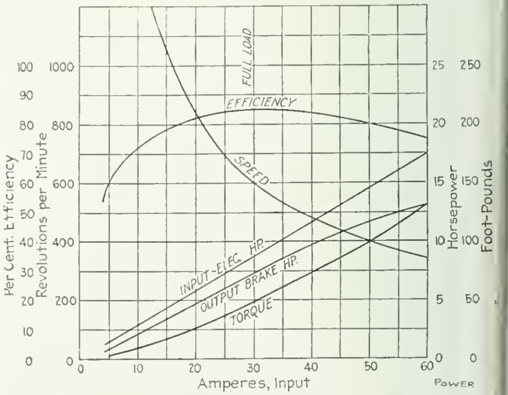

Fig. 5. Characteristics of Series Motor

Compound-wound motors are used largely for elevator service where a heavy starting torque and a fairly constant running speed are required. They also find many industrial applications for pumps, compressors, shears, reciprocating machine tools, etc., where irregular loads with severe peaks are encountered together with a demand for fairly constant rotative speeds. Furthermore the compound motor is well adapted for use on circuits subject to voltage fluctuations, such as trolley circuits. This is because an increase in voltage tends to increase the speed to enable the counter voltage to increase. An increase in speed is attended by an increase in load. The series turns of the field therefore increase their effort and strengthen the magnetism. This helps to increase the counter voltage. Therefore, an increase in voltage is not attended by as great a speed change for a compound-wound motor as would be the case were a shunt motor used. For this service then, the compound motor operates more uniformly.

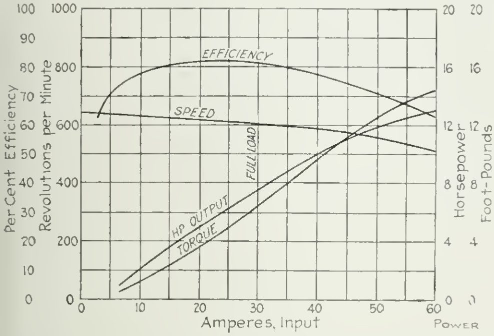

Fig. 6. Characteristics of Compound Motor

Speed Control

It will be noted that in the types mentioned, the changes in speed are automatic, a given speed in each case corresponding to a given load. However, it is possible to control the speed of a direct-current motor by external means. Returning to the fact that the speed is dependent upon the intensity of the field magnetism, it will be seen that if the field current be changed the magnetism is changed and the speed is affected in a corresponding degree. Therefore, if a variable resistance is connected in series with the shunt field of a shunt motor or a compound-wound motor, having a small degree of compounding, it is easy to adjust the speed to any desired point. The speed will then remain approximately constant at that point regardless of changes in load. The motor is designed to operate at the lowest speed in its range as a simple shunt motor. As resistance is introduced into the shunt field circuit, the speed increases until a point is reached such that centrifugal stresses or commutating conditions prohibit further increase. Motors are commercially built with speed ratios of two to one, three to one or four to one, and they have been built for ratios as high as six to one. In other words, the maximum speed may be two, three, four, five or even six times the minimum speed and the motor may be operated at any intermediate speed, the number of increments of speed depending upon the number of divisions of resistance in the controller.

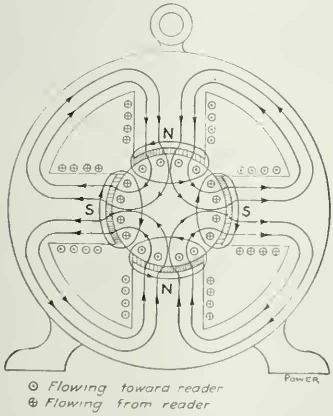

Fig. 7. Illustrating Cross-Magnetizing Effect

The factors which limit the horsepower rating of an adjustable-speed motor are heating and commutation, the maximum temperatures being obtained ordinarily when operating at minimum speed. Consequently the frame size must correspond to that of a constant-speed motor rated at the speed corresponding to the minimum speed of the adjustable-speed motor. A 5-hp., 400 1600-r.p.m., adjustable-speed motor and a 5-hp., 400-r.p.m., constant-speed motor are approximately the same size. Motors designed for low speeds are much larger and more expensive than those delivering the same horsepower at higher speeds, due to the larger torque required per horsepower output at low speeds. This being the case, a drive using a variable-speed motor is usually more costly than one using a high constant-speed motor with mechanical speed-changing devices.

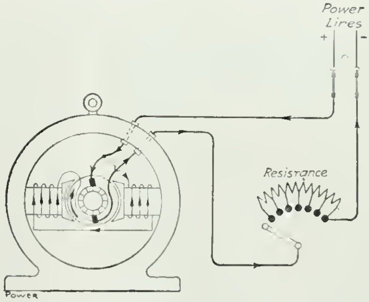

Fig. 8. Shunt Motor with Resistance in Series with Armature

Commutating Poles

As previously stated, speed control in adjustable-speed motors is obtained by decreasing the field magnetism. When the field is weakened the effects of "armature reaction" are apt to cause sparking at the brushes. The armature is made up of an iron drum with coils embedded in slots in its surface. The current flowing in these armature coils when the motor is under load sets up a magnetic field acting in a way similar to an electromagnetic coil; this action will be seen from Fig. 7, which illustrates the cross-section of a motor and the so called "cross-magnetizing" effect of the field set up by the current in the armature coils. This action is called armature reaction and its effect is to shift the "neutral point" or position where the brushes should be located. The greater the load the more the neutral point is shifted in a direction against the rotation. When the field is weakened in an adjustable-speed motor the relative effect of the armature magnetizing force is greatly increased.

the neutral is shifted quite materially and sparking results.

It has been discovered that a set of narrow poles may be introduced midway between the main poles and if these are properly magnetized they will oppose the cross-magnetizing effect of the armature. As the latter is roughly proportional to the load the magnetizing effect of these "interpoles" should change in a like manner. This result is attained by connecting the interpole coils in series with the armature so that the same current flows through the interpole and armature circuits. Practically all adjustable-speed motors are now supplied with interpoles, and they are also being used extensively in constant-speed motors for 500-volt service or wherever commutation is likely to be imperfect without their use.

Adjustable-speed motors are widely used for individual drives where speed control is desirable, especially for machine-tool work. The ease with which the speed may be changed is a strong factor in obtaining maximum production from all machines, the outputs of which are dependent upon the speed.

The speed of a motor may be decreased by decreasing the voltage impressed upon the armature. This is due to the fact that when the impressed voltage is reduced the counter voltage needed is also reduced and the motor will decrease its speed to decrease the counter voltage. Fig. 8 shows a shunt motor with a resistance connected in series with the armature circuit. The armature current flowing through this resistance causes a drop in voltage, so that the voltage at the armature terminals is less than that of the line. By changing the amount of resistance in the controller, the speed of the motor is adjusted. This method of speed control has two great disadvantages for most service requirements; namely, unsteadiness and inefficiency. If an increase of load occurs, the armature current will be strengthened and this increased current through the controller resistance causes a greater drop in voltage at the armature terminals; the speed, therefore, drops. It will be seen then that with this method of control the speed fluctuates with every change of load.

It will be remembered that for the field-control method of adjusting speeds, a resistance was inserted in the shunt-field circuit. The shunt-field current being only about 2 per cent. of the total current, the loss of power through the inserted resistance is small. In the armature-resistance method of control, the entire load current passes through the resistance, and a considerable loss of power results.

The armature-resistance method is used almost exclusively for traction service, for cranes and hoists and for operations where the speed is constantly manually adjusted. It is also used for printing-press drives and for blowers and fans where the maximum motor capacity is required at high speeds, where the torque at a given speed is quite constant and where the reduction of load under decreased speeds lessens the losses considerably.

The armature resistance method of speed control is used in practically all sizable direct-current motors at the starting period. The load current in a motor was shown to be controlled by the counter voltage. At the instant of starting the motor from rest, no counter voltage exists and if the full line voltage were impressed upon the terminals of a motor at rest, an enormous current would flow through the armature, causing trouble and likely affecting the source of power. To obviate this the motor is first connected to the line through a resistance in series with the armature. This is cut out in steps as the motor attains speed and the starting current is kept within the limits of usually 150 per cent. full-load current. This starting arrangement is called a starting box or rheostat, and is shown in Fig. 9. Most starting boxes are provided with a no-voltage release attachment, which automatically holds the starting lever in running position, as long as the line voltage holds. In case the supply voltage fails, the lever is released to the off position, so that full voltage cannot be impressed upon the motor at rest.

Fig. 10 illustrates a starting box combined with field control resistance. The circuits are arranged so tha the motor is brought up to speed with full line voltag impressed upon the shunt field. The field being stron the starting torque is heavy and the starting current low The large segments are the starting contacts and th small segments are the field-control contacts.

Fig. 11 shows a drum controller. These are largel used with series motors, and are often provided with magnet which draws the arcs at the contact points.

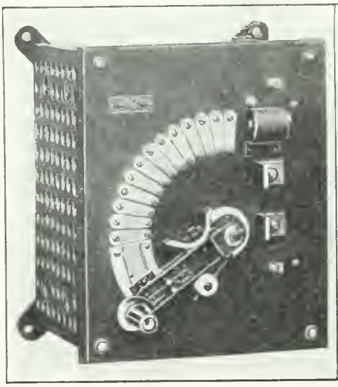

Fig. 9.

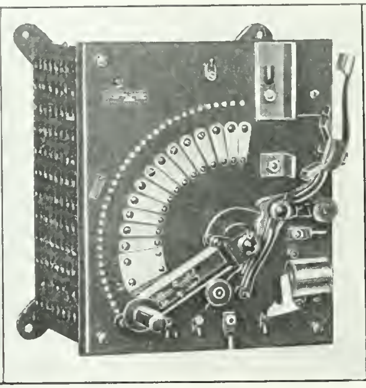

Fig. 10.

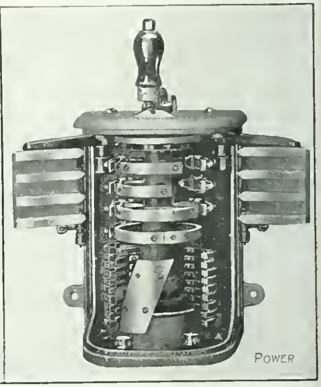

Fig. 11.

Types of Starting Rheostats

Fuel Economizers

By Lewis Jones

NOPSIS—A short statement of the conditions which ermine whether the installation of a fuel economizer likely to prove profitable or economical.

*

A fuel economizer is usually made of vertical cast-iron es, arranged in banks in the path of the hot flue gas ween the boiler and the uptake, through which the feed ter passes in a counter direction toward the boiler. at is transferred to the water in proportion to the tem- rature difference between the gas and water and the a of the tube surface. Ordinarily from 25 to 35 per t. of the total heat of the fuel escapes by way of the mney. All of the heat abstracted by the economizer m the flue gases constitutes a proportionate gain.

The function of the economizer is identical with that the feed-water heater using exhaust steam. The dif- ence is in the temperature of the exhaust steam and t of the flue gas; the former, at atmospheric pressure, only 212 deg. F., while the latter sometimes ranges as h as 600 to 700 deg. Therefore, the water can be sed to a much higher temperature in the economizer n in the exhaust-steam heater.

There is another advantage in heating the water to a h degree before it enters the boiler—i.e., the scale- ming elements in the water are, to a large extent, ar- ted and precipitated into the sediment chamber of the nomizer in the form of sludge, which can be easily shed out and does not enter the boiler. The same re- t is sometimes accomplished by using a live-steam ter. As the exterior surfaces of the economizer tubes umulate soot rapidly, on account of the lowered gas perature and the sweating effect, mechanical scrapers almost always provided; they, however, must be in stant motion to keep the tubes reasonably clean. The ciency of the economizer, like that of a boiler, decreases idly with the accumulation of soot.

The proportion of heating surface in the economizer that of the boiler or boilers to which it is connected, ends on the relation of the heating surface to the te area in the boiler and on the operating conditions general. If, for any reason, the boiler is unable to tract the heat generated in the furnace, the flue gas l be excessively hot, requiring a greater amount of sur- e in the economizer to take up this heat. At the same e, it will increase the temperature of the feed water a greater extent, and will effect a higher evaporation pound of coal. The proportions recommended by the nufacturers are from 2½ to 5 sq.ft. of tube surface boiler horsepower, or from ¼ to ½ the boiler-heating face, when the flue gas ranges from 350 to 650 deg.; en its temperature is not over 350, there is little bene- in allowing more than 2½ sq.ft. of surface per boiler- sepower in the economizer.

The returns to be expected will be from 15 to 35 per t. in capacity and from 7 to 15 per cent. in economy. is obvious that the percentage of saving (economy) the increased capacity need not necessarily be the e, because the evaporation per pound of coal may be ter, while the demand for steam remains the same; in the other case, the capacity may be greatly increased sacrificing the economy to this end.

Whether the results are likely to be satisfactory will depend on the purpose—i.e., whether to supply a demand for increased steaming capacity or for economy in the use of fuel.

The two questions are: If intended for greater capacity, will it supply the desired amount, or will an additional boiler be more desirable or even ultimately necessary? If for economy, will it pay as an investment?

The capacity is mentioned first because, if it is to be depended upon for a definite increase in steaming capacity, greater care is necessary to obtain data in order not to be disappointed, if a certain increase in *capacity* is imperative and the economizer fails to produce it, the condition is more serious than if a certain *economy* is expected but not realized.

Primarily, the temperature of the flue gas should be tested. If it is high, why is this so? Is it because the boiler is operated beyond its economical capacity and the heating surface is insufficient, or is it because the boiler is foul from soot and scale? If the former, an economizer will increase both the capacity and the economy of the plant. If the latter, it is likely that little benefit will be derived, notwithstanding the high gas temperature, because the economizer is also likely to be neglected. Will the 15 to 35 per cent. of extra capacity be sufficient, or will an extra boiler also be necessary with the economizer?

If considered for economy and not extra steaming capacity, will it pay as an investment? The accepted average saving in fuel is one per cent. for every 11 degrees increase in temperature in the feed water, or a fuel saving ranging from 7 to 15 per cent., less the operating costs.

The difference in the temperature of the gas on entering and leaving the economizer will indicate the amount of heat absorbed by the water. This, in turn, is determined by the temperature of the feed water on entering and leaving the economizer. If no exhaust is available to heat it, then the economizer has the entire heating function to perform, and will produce correspondingly greater results as the entering water is colder.

It is important that the temperature at which it is sent to the economizer should not be less than about 100 deg.; in many cases, the temperature is considerably below this, and causes what is known as dewing or sweating of the pipes. The result is that the vaporous portions of the flue gas condense on the bottom boxes and lower ends of the pipes, causing rapid corrosion; also, the soot cakes hard on the tubes and in time prevents the scrapers from working.

The counterflow principle allows the colder feed water to come into contact with the cooler gas, and advance

The kind of draft, natural or artificial, also enters into the investment consideration. If natural draft is abundant, it is likely to cause excessive air in the furnace, with low CO_2. The greater the excess of air used per pound of coal burned, the greater the proportion of saving the economizers should show. An economizer will tend to correct both losses by slightly reducing the draft, and also by absorbing the heat from the excess heated air. If, however, the natural draft is near the minimum, it is likely that the reduction in the gas temperature and the obstruction by the economizer will prove too much, re quiring a forced or induced-draft fan equipment. In this case, the first cost is enhanced and the operating cost is greater; therefore, the proposition becomes less attractive. If, in the third case, the draft is bad, a fan will prove profitable with or without the economizer, and should not be charged against the first cost of the economizer equipment: nor should all the good results be attributed to the economizer.

The loss in draft in the economizer is from 0.15 to 0.40 in. of water. Cost of maintenance and upkeep must be taken into account, because no part of the plant will show a wider range of results due to care or neglect than an economizer. Therefore, if the plant is kept in the best condition, and the best results are obtained with a given equipment, the economizer will probably be well taken care of and prove a good investment: but if losses are due to neglect or ignorance of either the employer or the employe, then the addition of an economizer becomes a questionable proposition, or even detrimental and sometimes dangerous.

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Down-Draft Furnaces*

By Osborn Monnett†

SYNOPSIS—Principles of operation, provisions for preventing smoke and how to fire this type of furnace.

⁂

These furnaces depend for their success on the fact that the volatile matter must pass down through the bed of fuel and over the coked coal on the lower grate before entering the boiler. In this way the gas is exposed to a high temperature, and if the proper amount of air is admitted through the middle door, it will be consumed without making smoke. When poking the fuel bed, it frequently happens that considerable green coal will be brought down on the lower grate: it will smoke unless special precautions are taken.

Fig. 1 shows a typical down-draft furnace connected to a horizontal return-tubular boiler. If operated rightly, this furnace can be run without dense smoke, but with the ordinary fireman there are periods when, through careless operation, a quantity of volatile matter passes the bridge-wall without being consumed and escapes as smoke. To get the best smokeless results on this furnace, some additional protection against these periods is necessary. Fig. 2 shows a down-draft setting with a deflection arch and with the bridge-wall arranged to give the maximum deflection of the gases. This arch mixes the gases thoroughly before they pass away from the furnace and is of great aid in preventing smoke.

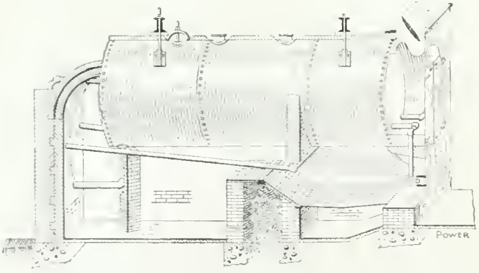

Fig. 1 Ordinary Installation of Return-Tubular Boiler and Down-Draft Furnace

Another step taken to increase capacity and lessen smoke is shown in Fig. 3. It is a modification of the standard double-arch, bridge-wall setting as used for hand-fired settings, in connection with a deflection arch as before. This construction seems to have a marked effect on the rate of combustion and consequently the capacity of the boiler and also on the smoke. If properly operated, it is as nearly smoke-proof as any semi-stoker or hand-fired arrangement can well be.

Fig. 4 is a working drawing of a down-draft furnace and a single-span deflection arch in connection with a 60-in. by 18-ft. boiler. With this as a guide, a setting for any size of boiler can be worked out, using the same rules for areas of gas passes that have been previously set forth for hand-fired furnaces with deflection arches.

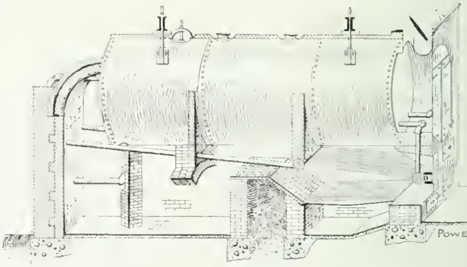

Fig. 2. Down-Draft Furnace with Deflection Arch in Combustion Chamber

In combination with water-tube boilers, the down-draft furnace can be easily applied, the principal requirement being that the boiler must be horizontally baffled. Fig. 5 shows a standard Kroeschell setting with down-draft grates and a two-span deflection arch. This makes a good hand-fired, flush-front outfit for moderate rates of combustion.

It is not feasible to apply the down-draft furnace to vertically baffled water-tube boilers and still get the desirable flame travel and mixture. While a few such settings exist, for power loads the design cannot be considered good for smokeless operation with high-volatile coals.

Building Fires

Cover the lower grate with coal and build a wood fire on top, keeping the middle doors cracked for the panels wide open. After this fire is well started, throw a little wood on the upper grate and cover it with coal, allowing this fuel to be ignited from the lower fire.

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

In regular firing, after a good bed of coals has been formed on the upper grate, poke the coked coal down on the lower grate and cover the upper grate with fresh coal, keeping the fuel bed at thick as the draft will permit; the thicker the better. When poking down, always crack the middle door to allow plenty of air to take care of any volatile matter which may pass off. The more coal kept on the upper grate, the thicker will be the bed of coked coal, and consequently the less chance of making smoke. Never poke down until the coal on the upper grate is thoroughly coked. Be careful that no green coal comes down on the lower grate. Regulate the steam by opening or closing the front firing doors. The less the lower grate is disturbed, the better. There should be no regular cleaning period for the lower grate as is common for the ordinary, hand-fired grates. Clinkers should be pulled out from time to time without disturbing the coked coal, thereby always keeping the lower fire in good shape.

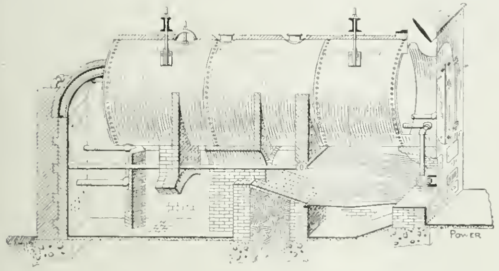

Fig. 3. Down-Draft Furnace with Double-Arch Bridge-Wall and Deflection Arch

The secret of success with this type of furnace is to fire heavily on the upper grate; it permits long periods between firing, during which there is a thick bed of coal being coked. When the fire is poked down, this thick bed insures that there will be no green coal falling on the lower grate. In this way, the fires need be disturbed only at infrequent intervals and there is no danger of dense smoke if ordinary care is exercised. This type of furnace should not be expected to run at a rate of combustion higher than 25 lb. of coal per sq.ft. of grate surface per hour, based on the area of the lower grate. Above this rate the chances of making smoke are increased, due to frequently disturbing the fire. Below this rate the furnace is eminently suited to the work and it is not necessary to be particular as to the kind of coal used, although a 4-in. run-of-mine coal is ideal for a down-draft furnace.

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Safety First—The "Safety-First" slogan is a practical, worthy attempt. Results, however, can only be reached when all unite in an effort to further the commendable work.

⁂

Belt Cement—The following is the composition and use of a belt cement which is said to work equally well on leather and rubber belts: Carbon bisulphide 10 parts, mixed with turpentine one part, with enough gutta percha dissolved in the mixture to make a thin syrup. Both parts of the leather to be joined must be clean, and if they are greasy they should be laid on a clean rag and a hot flatiron placed on them so as to draw the grease up and let it be absorbed by the cloth. When the surfaces are free from grease they are coated with the cement and kept pressed together until the joint has set hard.

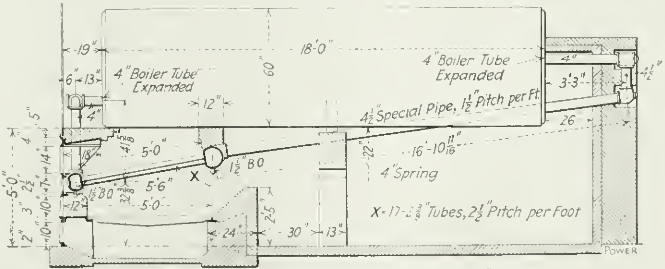
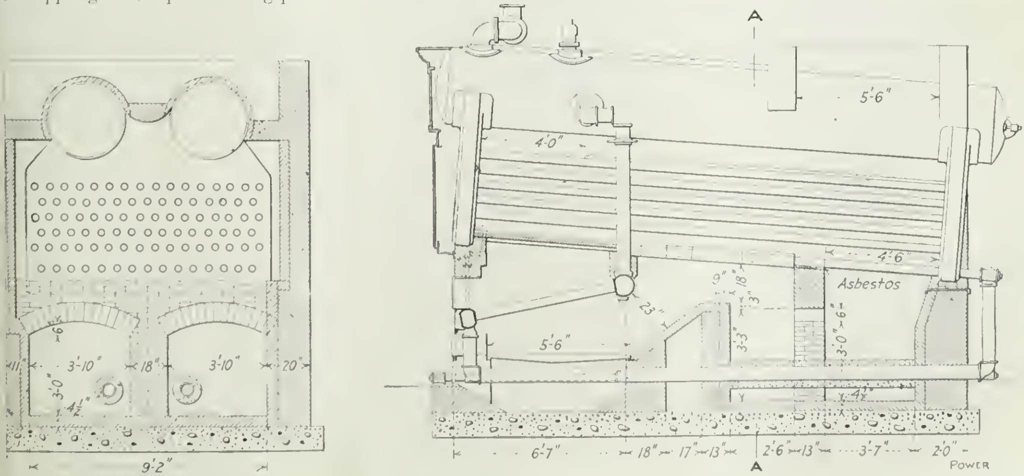


Fig. 4. Working Drawing for Furnace Shown in Fig. 2, 5x18-Ft. Boiler



CROSS SECTION A-A

LONGITUDINAL SECTION

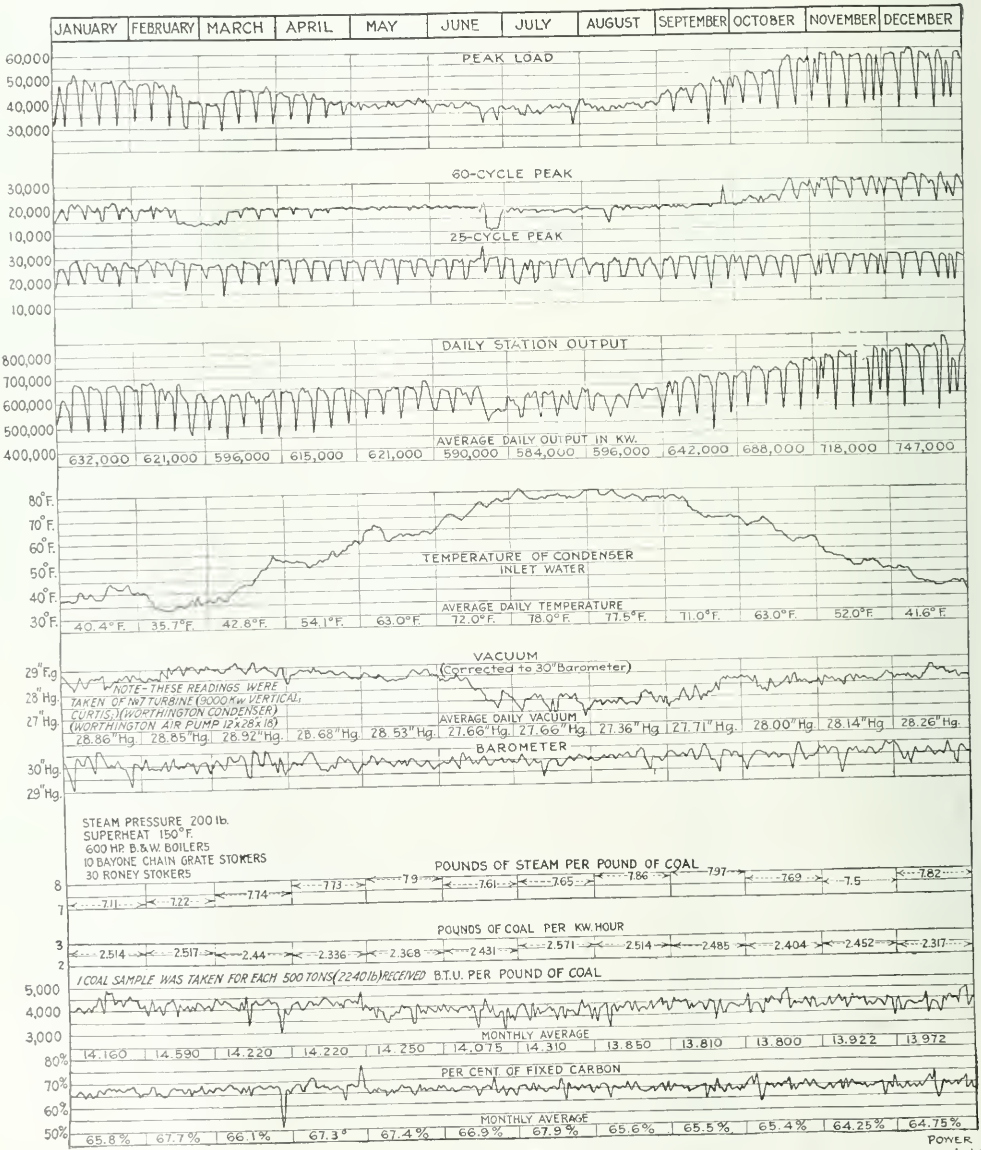
Fig. 5. Kroeschell Boiler, 204-Hp., Equipped with Down-Draft Furnace and Deflection Arch

Performance of Marion

The Marion (Jersey City) Station of the Public Service Corporation of New Jersey, located on the Hackensack River, is the largest of this company's many power stations. The accompanying curves show in detail the performance of the station for 1913.

Notice that the coal used is higher in volatile than that used in most stations, running as high as 29 per cent. at times with an average of 24.7 per cent. for the year. The location favors this coal as far as smoke is concerned, but as it is a rather long-flame coal the floor under some of the boilers has been lowered two feet and more to give additional furnace height.

Usually in calculations the average temperature of circulating water is taken as 65 or 70 deg. F. It is inter-



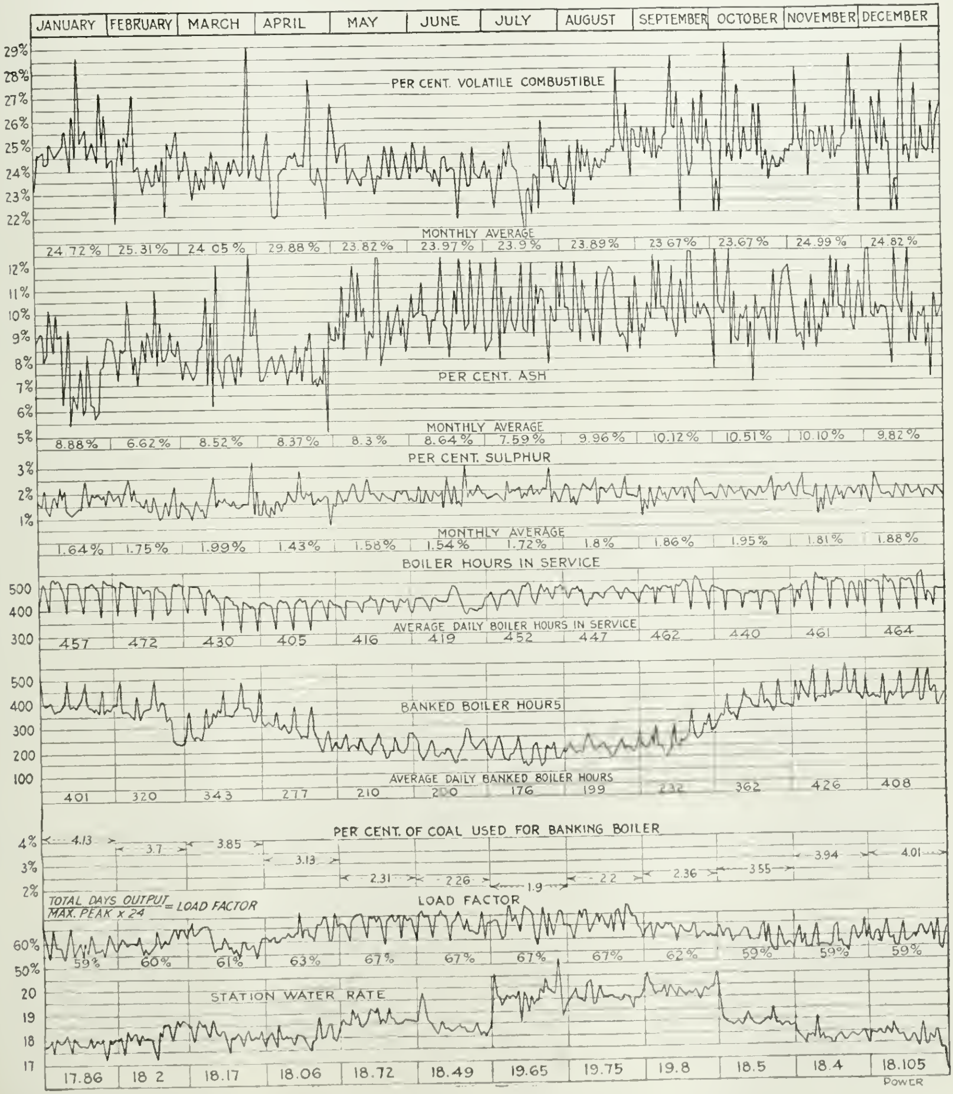
Note—It will be noticed that the "1's" have been unintentionally omitted in the figures giving the heat values of the coal; they should, of course, be 13,000, 14,000 and 15,000.

Station for the Year 1913

esting, therefore to note that the average temperature at Marion was 57.5 deg. F., with a maximum of 82 and a minimum of 33 degrees. Notice that this curve is comparatively flat for July and August. The barometer shows a much wider variation for January than for any other month.

The steam rate for July, August and September is quite perceptibly higher than for any other three months, being 1.65 lb. higher than for January, February and March. This is due chiefly to the vacuum owing to the warmer condensing water used in the summer months. For January, February and March the average vacuum was 28.88 in., while during July, August and September the average was 27.53.

The coal used per kilowatt-hour for the year averages 2.44 lb. This is not a bad showing when it is considered that all standby, leakage and blowoff losses are included in this figure. This is 0.696 lb. higher than the figure given



Note—The above figures are not the average of the station water-rate curve, but are the averages of the above curve plus steam used by cable testing, construction, and condensation losses.
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by the Boston Elevated Railways Co., for the performance of its South Boston Station for 1913, the consumption being 1.744 lb. per kilowatt-hour including losses for banked fires and leakage. The coal used in the South Boston Station has about the same heat value as that used in Marion and is straight bituminous slack.

The curve showing the percentage of the total coal used for banked fires follows the station and peak load curves very well, reaching a maximum of 4.13 per cent. for January as against a minimum of 1.9 per cent. for July, the average for the year being 3.1 per cent., or almost exactly the percentage used in April.

⁂

Comparative Tests with Low-Grade Oils

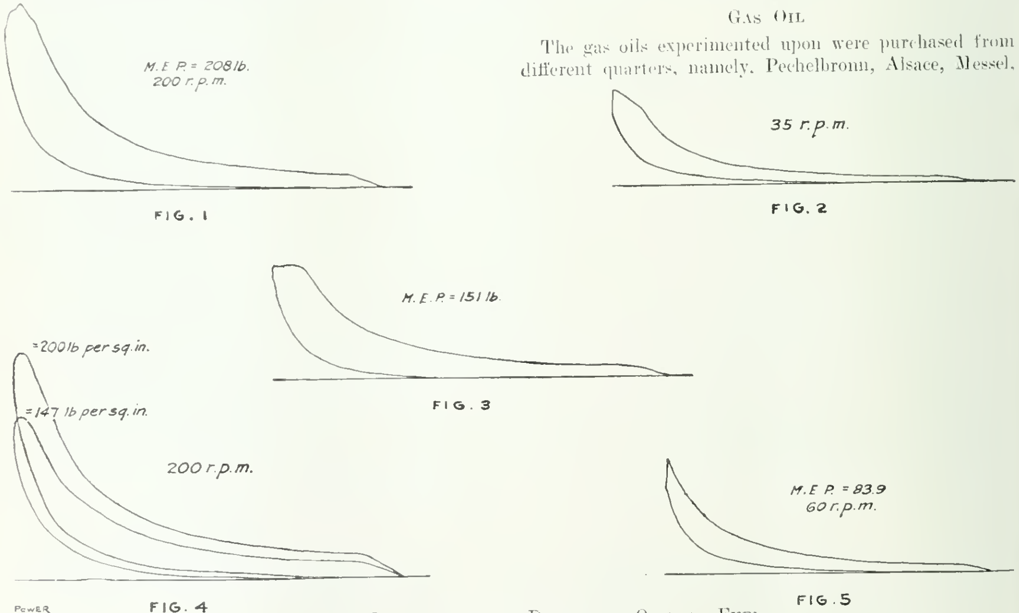
By Dr. F. E. Junge

SYNOPSIS—Results of tests on a Junkers engine to determine the performance with different low-grade oils, including those of asphaltic base and coal-tar oil.

⁂

The increasing application of liquid fuels for purposes of power generation, where weight, space and economy are limiting conditions, has made it necessary to turn from the use of high-grade oils, so far employed, to the utilization of lower grades, which are available all over the world in large quantities or remain suitable for further use as byproducts of the distillation of coal and crude mineral oils.

In the following, the results of fuel-consumption trials on a Junker engine are given, containing, among others, the results of tests made with Californian and Mexican crude oils, the lowest grade of liquid fuels in existence. The engine used in these tests had a cylinder diameter of 7.8 in. and a stroke of 2 × 15.6 in. (two opposing pistons being employed). The speed was 200 revolutions per minute, the normal load 150 horsepower, and an overload attained of 220 horsepower. The engine has two cylinders arranged in tandem, but having been designed for experimental purposes and being the first double-piston engine of its type actually built, it contains few of the many improvements which have since been made: therefore the results are not as favorable as would be expected with a later design. Also, for experimental purposes, it is equipped with much larger pumps and compressors than necessary for normal working, the scavenging pumps having nearly twice and the compressors nearly five times the normal capacity.



Indicator Diagrams with Different Oils as Fuel

Gas Oil

The gas oils experimented upon were purchased from different quarters, namely, Pechelbronn, Alsace, Messel, near Damstadt, and Wietze, near Hanover; Roumanian and American gas oils were also tested. The analysis of the oils and the results obtained are compiled in the accompanying table. It may be added that the engine was run for several hours at 30 and 40 r.p.m. at 20 per cent. turning moment. After stopping two hours the engine started on gas oil without the use of compressed air.

Attention is called to the high mean pressure and to the high thermal efficiency attained. The fuel-consumption figure in the first column refers to gas oil having a calorific value of 10,000 calories per kilogram or 18,000 B.t.u. per pound.

Pacura Oil

It was decided that long duration trials should be made in frequent intervals, in preference to continuous trials, the former being more likely to show any tendency to leave a deposit on the pistons or cylinder walls. Altogether 6600 lb. of Pacura were consumed during the trials. Immediately afterwards the pistons were taken out and an examination of the cylinder, ports, pistons, and fuel valve showed them to be clean. There was no disturbance whatsoever during the whole of the trials and the fuel consumption remained constant, averaging 0.44 lb. per brake-horsepower per hour. The thermal efficiency showed a mean value of 31.6 per cent. and the mean effective pressure was in the neighborhood of 160 lb. Pacura is a Roumanian residue oil, the specific gravity and flash point of which are given in the table.

Californian Oils

Two brands of this oil were tried in the engine, Californian residue, brand "L," and Californian crude oil, brand "K"; both were obtained from the Amalgamated Oil Company's refinery at Los Angeles. Analysis of the latter is given in the table. The trials extended over a period of four weeks, the aggregate period of operation being 126 hours. An overload run was also made, followed by a number of trials at low speeds, 25 to 30 r.p.m. being maintained with uninterrupted positive ignition. Attention is called to the high contents of asphaltum in the fuel, in spite of which no trouble whatsoever was experienced throughout the trials, the pistons, atomizers, fuel valve, etc., remaining untouched during the whole period. After the conclusion of the trials when about 11,000 lb. of oil had been consumed, the pistons and other working parts were removed, inspected and photographed. There was no deposit on the piston heads and the nozzles were clean, proving that the temperatures in this type of engine combined with the perfect process of scavenging and charging were capable of consuming Californian crude oil completely. The indicator diagrams, Figs. 1 and 2, are particularly interesting, because the first was taken under abnormal conditions of overload, showing a mean pressure of 208 lb., while the latter shows perfect ignition at 35 r.p.m.

Mexican Crude Oil

This oil was supplied by the Huasteca Petroleum Co., of Ebano, Mexico, and its analysis shows it to be about the worst fuel obtainable, containing as much as 15.6 per cent. asphaltum and 2.4 per cent. sulphur. The engine was run on this oil each day for a period of 10 to 12 hours, altogether 200 hours. One day it was run for 11 hours on 50 per cent. overload, but in spite of the high percentage of asphalt, it is said to have operated throughout the trials without the slightest trouble. At speeds as low as 25 and 40 r.p.m., ignition was positive and the engine ran well. The indicator diagram in Fig. 3, taken at normal load, shows a mean effective pressure of about 151 lb.

Russian Masut

Analysis of this oil showed the incombustible matter to be made up to 1.06 parts water and 0.37 part ash, making a total of 1.43 per cent. A long duration trial of 75 hours was held during which no difficulty whatsoever occurred and the exhaust was always invisible. An inspection of the internal working parts immediately after the termination of the trials showed all parts to be in good condition.

German Coal-Tar Oils

This oil had lower calorific value and a higher carbon content than the other fuel oils. Its specific gravity was also higher. The engine ran well and started easily without the use of ignition oil. The indicator diagrams, Fig. 4, at normal load and overload, shows the more spontaneous character of ignition of the coal-tar oils compared to other fuels. The last indicator diagram, Fig. 5, shows the engine at 60 r.p.m., that is about one-third normal speed, and at one-third normal load, running on tar oil alone and igniting with ease and certainty.

RESULTS OF TRIALS WITH DIFFERENT OILS

Analysis of oil	Gas Oil	Pacura	Calif. Oil	Mexican Oil	Masut	Coal Tar Oil
Heat value, B.t.u. per lb	18,000		17,400	17,460	17,800	15,950
Carbon, per cent.	86.98		84.0	83.21	85.67	90.12
Hydrogen, per cent.	12.15		11.07	11.32	12.13	7.09
Sulphur, per cent.	0.71		0.87	2.47	0.05	0.63
Oxygen, per cent.	0.16		3.93	2.90	0.72	1.66
Incombustibles, per cent.	0.00		0.13	0.14	1.43	0.50
Specific gravity	0.850	0.90	0.864	0.937	0.900	1.065
Viscosity	1.14		6.41	4.11	19.96	1.66
Flash point, deg. C	80	140	137		113	98
Asphaltum, per cent.			48.1	45.6		
Average mean ind. pressure, lb. per sq.in.	154.4	161.7	155.8	147.0	158.6	147.0
Thermal efficiency, per cent	33.1	31.6	30.5	30.4	31.8	32.1
R.p.m.	200	205	200	200	200	200
Brake hp.	160	154	151	145		144
Fuel consumption, lb. per b.hp.-hr.	0.427	0.440	0.480	0.480		0.480

*

Drinking-Water Systems

Water, when cooled for drinking purposes, is best at from 45 to 50 deg. F. As to the costs of systems for cooling drinking water, it is claimed that in numerous cases a small refrigeration plant with cooling tank and fountains conveniently located has been installed for less than the operating cost for two years with the bucket and dipper method.

The quantity of water required per individual varies with the different industries and climatic conditions. In steel works, where the service is quite severe, it has been found that in summer, from 0.23 to 0.3 gal. per man per hour is necessary, including the waste.

The amount of refrigeration depends on the size of the installation, the length of the distributing lines, the outside temperatures, the temperature of the water, the length of the day in which the system is to be in service and quite important, on the manner in which the pipe lines are insulated. Experience shows that 0.00027 to 0.0005 ton of refrigeration per hour per man is needed.

It is good practice to use galvanized pipe with long sweep fittings for the distributing lines. At the return bend of each circuit a thermometer and a gate valve should be provided for regulating the flow, so as to insure uniform temperature throughout the circuit. Dead ends should, of course, be avoided. Branch circuits will give best results if made not longer than 2000 ft., though some as long as 5000 work quite satisfactorily. One-inch pipe will be found a good size, though the number of drinkers may require larger sizes on some circuits. Extended observations show that a water velocity of not more than 190 ft. per minute gives the best results.

All this is told very clearly in a little booklet containing several photographs and diagrams, as well as an interesting description of the plant at Beaver Falls, Penn., the testing station for the Armstrong Cork & Insulation Co., Pittsburgh, Penn., makers of Nonpareil cork pipe covering. We understand that the booklet may be had for the asking.

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Avoidable Heat Losses Prevented

The value of properly and efficiently insulating boiler settings, steam drums and all exposed heated surfaces in boiler rooms was recently demonstrated in the Chamber of Commerce Building, Detroit, Mich. The idea of thoroughly insulating the three 100-hp. water-tube boilers was inspired by the desire to reduce the heat in a storeroom over the boilers.

The steam drums and the tops of the boiler settings were covered with one course of Nonpareil insulating brick set on edge in special insulating cement; in all, 3100 bricks were used. Although the covering on the steam line was equal to that found in the average boiler room, it was replaced in numerous cases by Nonpareil high-pressure steam covering 2 in. thick. The breeching, valves and other irregular surfaces were covered with 2 in. of high-pressure cement.

One feature is the removable covers used on the steam-pump cylinders. Forms were made of Hy-Rib metal to which high-pressure cement was applied and afterward covered with canvas.

The result obtained by the use of these insulating materials was that the temperature under the floor of the storeroom above the boilers was lowered 30 deg., and made conditions in the store much more pleasant. The insulating material used was made by the Armstrong Cork & Insulating Co., Pittsburgh, Penn.

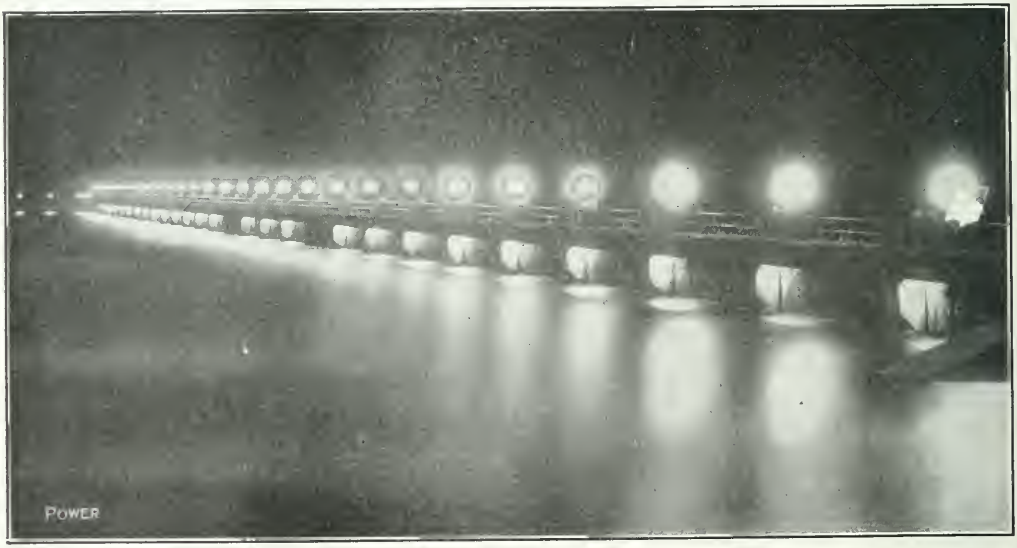
Accurate monthly records of the fuel consumption in this plant have been kept for a number of years. Since the load varies but little from year to year, it was a simple matter to compute the fuel saving due to insulation. During the month of April, 1913, 224,960 lb. of coal were consumed, and 229,950 lb. in May of the same year. In April, 1914, after the boilers had been insulated, but 183,190 lb. of coal were used, and in May, 1914, but 181,930 lb. Hence, the saving in April, 1914, over April, 1913, was 41,770 lb., and the saving of coal in May, 1914, over that of May, 1913, was 48,020 lb.

⁂

Coon Rapids Dam Illuminated

This dam, which is 2070 ft. long, with a concrete spillway 1000 ft. long, surmounted by 28 Tainter gates, each 33 ft. long and 8 ft. high, has been provided with 100 Mazda lamps, mounted on goose-neck standards. This illumination, illustrated herewith, is for the purpose of making safe passage of persons on the bridge over the dam, to facilitate the work of handling the Tainter gates and for dealing with the ice and log problems which will arise at certain periods of the year.

Two of the five generating units in the hydro-electric plant are in operation. The development is leased to the Minneapolis General Electric Co., and was built by H. M. Byllesby & Co., Chicago.



Coon Rapids Dam, Illuminated with 100 Mazda Lamps

⁂

Barometric Condenser Head as Open Heater—A railway master mechanic had use for large quantities of hot water in a roundhouse where there was very little room for a heater. Both live and exhaust steam were available for heating the water, but it was a question of getting a heater of dimensions which could be accommodated in the space. D. D. Pendelton, of the Wheeler Condenser & Engineering Co., suggested that the head of a barometric condenser be used as a mixer for the cold water and steam, and this was done successfully, the installation taking up a very small corner of the house.

Editorials

Large Steam Turbines

The article, "Compound Steam Turbine," in the Sept. 15 issue, and that treating of the Brooklyn Edison Co.'s new turbine, in this issue, are of interest for what they bring out regarding the development of this class of prime mover. To most of us, the chief feature is the great increase in capacities of turbine units in such a few years. In 1900, turbines of capacities greater than 500 kw. were so rare as to be regarded with much interest, particularly by those engaged in the design of this class of machine. Today, units of 20, 30 and even 35 thousand kw. capacity excite only momentary surprise, so rapid has been their development. Any day we may learn that some builder is beginning the construction of a 50,000-kw. unit, and there is no doubt that, with the cross-compound principles of design as adopted for the new 30,000-kw. unit for the 74th St. station, capacities greater than this are possible.

It will be with much interest that engineers will watch the operation of these immense compound units. Mr. H. G. Stott, superintendent of motive power for the Interborough Rapid Transit Co., always an original man and one of the foremost in the art, is as confident of their success as he was sure that he could safely and economically operate boilers considerably above their rated capacities, a practice that has been widely adopted, and one in which he was a pioneer. It is with the same feeling that Mr. Hodgkinson, designer of these machines, has completed his work.

The turbine for the Gold St. station of the Edison Electric Illuminating Co., of Brooklyn, is the largest single-cylinder unit, being of 25,000 kw., maximum rating. Additional interest is induced because of the use of single and compound construction for large turbines. Much apprehension was felt by foreign engineers when American designers put forth a unit of 2000 kw. with a single cylinder in 1900. Dangerously severe distortions were expected in so large a machine, due to the extreme temperature differences along the structure. European designers were then building 1000-kw. units with two cylinders placed tandem. Convinced of the superiority of the two-cylinder arrangement, American engineers adopted it, while at the same time those abroad increased the capacities of their single-cylinder machines, but apparently considered that a safe limit was reached for this design at a capacity below that practiced by American engineers. The Parsons 25,000-kw. machine for the Chicago Commonwealth Edison Co. is a two-cylinder tandem unit, while the Westinghouse machine for the Brooklyn Edison Co. has a maximum capacity of 25,000 kw., and is of the one-cylinder, double-flow type. Basing the areas occupied on over-all lengths and greatest widths, the Chicago machine develops 17.3 kw. per sq.ft. of floor space, while the Gold St. turbine produces 30.1 kw. for the same unit of area.

The increase in speed along with capacity is another point of interest. Especially is this so when we consider that for 25-cycle work, 3000 kw. was the highest capacity at the speed of 1500 r.p.m. in 1905, while the 22,000-kw. (normal rating) Brooklyn machine runs at 1500 instead of 750 revolutions. Relative to speed, it is of interest to know that the 20,000-kv.a. (80 per cent. power factor) single-cylinder turbines now being built by the General Electric Co. for the new Essex station of the Public Service Corporation of New Jersey will run at 1800 r.p.m., the highest attempted in large turbine practice.

As we have probably reached the limit in forms of design for large units, now that the "cross-compound" with two speeds is a reality, we may perhaps look only for continued developments in details.

*

Waste of Natural Gas

As a result of the general conservation movement promulgated during the past few years, the public, and engineers in particular, have awakened to the necessity of conserving the nation's coal supply, and have responded, in a measure, by furthering hydro-electric development and by practicing boiler-room economy. Up to recently, however, little thought appears to have been given to the enormous waste going on in the oil and gas regions.

Investigations by the Bureau of Mines, the results of which are published in a recent bulletin, show this waste in the midcontinent fields, comprising Kansas, Oklahoma and northern Texas, alone to have been appalling. It is estimated that up to last year, 425 billion cubic feet of natural gas, equivalent in heat value to over 20 million tons of coal, have been allowed to escape, and although the waste has now been curtailed to some extent, it is still over 25 billion cubic feet per year, equivalent to over a million tons of coal. Much of this gas appears in combination with oil, and where there was no immediate market, it was often allowed to go to waste, being regarded merely as incidental to the production of the oil. Only of comparatively recent date have steps been taken to produce gasoline from the gas, but even this process has not become general.

The waste in this region is not confined to the operators alone, for when the gas is collected and piped to consumers, in many cases it is sold at a flat rate, without meters. This, combined with the low price, which for the state of Oklahoma averages about 5c. per 1000 cu.ft., is conducive to the existing practice in many cases of allowing lights to burn night and day, and of regulating the temperature in cold weather by opening outside doors.

While legislative action might be directed at the prevention of such waste, its effectiveness is doubtful, as it would be difficult to enforce any drastic measures of this nature. As in the case of coal, the remedy undoubtedly lies in educating both the producer and the consumer to the economic aspects of the problem in such a way as to show them that they will personally profit by conserving the supply.

The License and Boiler Inspection Law Hearing

The committee appointed by the American Society of Mechanical Engineers to formulate standard specifications for the construction of steam boilers, and the care of the same in service, held a hearing at the Engineering Societies' Building in New York last week, which was the most momentous and potential occasion which has occurred in the battle for legislation for the reduction of boiler explosions and steam-plant accidents.

A seeming attempt to pack the committee interfered with the orderly progress of the proceedings at first, and lack of harmony between the representatives of the railroads and of the steel manufacturers and the committee threatened to prove a serious hindrance to a successful outcome of the work, but the indorsement of the general purpose was so hearty and general, the determination to have some legislation of this kind so positive, that a spirit of compromise prevailed. The committee withdrew some of its most radical provisions without materially affecting the standard of its code, perhaps with the effect of avoiding serious difficulties in its enforcement, and the representatives of the interests professed their satisfaction.

There is evidently still a great amount of work to be done to perfect a code which will take account of the suggestions offered, and the completed report of the committee can hardly be ready before the December meeting of the society. In the meantime, the boiler manufacturers have worked up a live interest in the subject on the part of the governors and legislators of many states, and these are demanding something concrete in the way of a suggestion for their legislatures. Mr. Durban, speaking for the boiler manufacturers, demanded some sort of a result which could be turned over to these people within 30 days, and we understand that a new organization, comprising all the boiler manufacturers, has been formed to meet in Pittsburgh on September 29 and consider methods for promulgating this sort of legislation either by forwarding the work of the American Society of Mechanical Engineers committee, or by getting out a law and standard upon its own hook if the work of that committee does not progress at a satisfactory rate. The boiler makers are in entire accord with the A. S. M. E. committee, although they may not be particularly interested in an engineer's license law, which is a part of the committee program, and if they go to work independently it will be simply because the society's committee does not keep the pace at which they wish to go.

The main part of this work, however, is to be done upon the code, and the code is no part of the law which will have to be passed by the various states to bring the code into effect. The law provides a Board of Boiler Rules, and the code, which comprises the bulk of the report, and includes all of the disputed points, is what the Board of Boiler Rules is supposed to adopt after it has been legislated into existence and appointed. It would seem therefore that the work necessary before the meeting of the legislatures could be very expeditiously done. A general form of the law, not so specific as that which the committee included in its preliminary report, which is practically that of Massachusetts, but a form which can be varied to adapt itself to the usages and constitutions of the various states, should be prepared with footnotes for the guidance of legislators availing themselves of it. This should be done by a lawyer rather than an engineer, and by one having legislative experience.

If the code goes through, as apparently agreed at the hearing, all boilers will be hereafter figured on a tensile strength of 55,000 per square inch. The steel manufacturer is allowed a range of 8000 pounds, and the finished plate must be somewhere between 55,000 and 63,000, but will be stamped 55,000, whatever it may test. It is not allowed to test over 63,000, for fear of brittleness. It would appear to be a more direct and logical way to insure ductility to specify ductility and not to restrict the tensile strength, and one wonders why the designer, customer or builder of the boiler is not allowed to call for any tensile strength desired, stipulating, however, that the yield point, elasticity, ductility, etc., shall be so and so.

An analogous lack of directness appears in the specification for the filling of fusible plugs. The committee suggested "pure" tin. A critic at the hearing wished that Banca tin be specified as by the Government for the marine service. It was pointed out, however, that there is practically no tin to be procured from the Isle of Banca. The degree of purity implied by the committee's specification might be brought into question. Obviously, the logical and simple way is to specify the melting point.

A great deal of difficulty will be avoided in the introduction of the law if the factor of safety, as applied to boilers already in operation, be not placed too high. The recommendations of the committee are based largely upon Massachusetts practice. In Massachusetts, many of the boilers have been built and insured upon high factors of safety, and the allowances for pressure are more conservative than in other parts of the country, 5 and 5½ being common. In the West, however, many boilers have been accepted for insurance with a factor of safety at 4. To jump this to 5½ means the cutting down of pressure to an extent which would seriously embarrass existing industry. For new boilers the embarrassment would not be serious, and the factor of safety could be placed at any reasonable figure, but it is doubtful if there is any record of a boiler having exploded on account of a too low factor of safety, and it would appear to be the part of wisdom to put the code through with a factor which would not be onerous to existing installations, and yet would insure a sufficient margin of safety. The strict supervision of the material and workmanship which the code implies ought to insure that the boilers built in future shall be little liable to explode, unless they are grossly abused, and the safety of the boilers now in use can be better guaranteed by keeping a close inspection upon them, lowering the factor of safety in specific instances as there seems to be occasion to do so, and letting them gradually work their way out of use.

There was considerable discussion as to whether the horsepower should be based upon the heating surface or the grate surface, but it did not seem to occur to anybody that the horsepower might be dispensed with altogether to advantage. There was also considerable discussion as to safety-valve capacity. This is not a question of precision anyway; all that is required is that there shall be opening enough for the safety valve to discharge all the steam that the boiler can make under the circumstances of its installation, or any installation to which it is likely to be subjected, and it does not matter how much more is provided up to a point which cost considerations would hardly allow to be involved. And, by the way, who ever heard of a boiler explosion occasioned by too small a safety valve?

Correspondence

Boiler Gaskets

For gaskets on boilers I make a braid out of ⅝-in. asbestos wick packing long enough to fit in the groove in the manhole plate. Then I cover it well with a thick paste of cylinder oil and flake graphite. I have used this kind of gasket on the front manhole plate where the hot gases strike the plate for a year without renewing. Every time I take the plate out I put more graphite in the depression made in the gasket, and if it leaks it is because it is not thick enough or has been in use for a long time and is too hard. I think this makes a cheap gasket and easy to make. I have never had a blowout.

Fritz E. Olson.

Brainerd, Minn.

[Several references have been made to lead boiler gaskets in recent issues. See page 604, April 28, page 24, July 7, page 70, July 14, and page 356, Sept. 8. The care of boiler gaskets is treated on page 30, July 7.—Editor.]

⁂

Lost or Reversed Residual Magnetism

For a direct-current generator to reverse its polarity is an ordinary occurrence, especially with compound-wound machines used to charge storage batteries. For a generator to lose its polarity entirely, however, is unusual. Under normal conditions, the voltage due to residual magnetism will be from 5 to 15 per cent. of the rated voltage of the machine, and a voltmeter applied to the brushes will indicate this, even when the field circuit of the machine is broken. With the residual magnetism entirely gone, a voltmeter across the brushes will indicate nothing. The accompanying diagram shows a compound-wound machine connected to a battery through a switch or breaker *K*, which normally is closed only when the generator voltage exceeds that of the battery, in which case the current flow is in the direction indicated by the arrows.

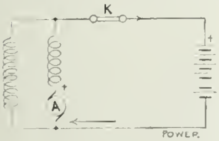


Diagram of Field Connections

Should *K* be closed with the generator voltage slightly below that of the battery, the polarity of the generator is not likely to be reversed, because the battery will send current through the shunt coils in the existing direction, and while current does flow through the series coils in the reverse direction, the series field will not be strong enough to reverse the stronger shunt field. Should *K* be closed with the generator dead, however, the comparatively low impedance of the armature and series field in series will short-circuit the high impedance of the shunt winding, with the result that there will be a heavy reversed series field magnetization, with only a comparatively light shunt field magnetization to oppose it. Under these circumstances, the series field will overcome the shunt field and reverse the polarity of the residual magnetism. Therefore, the next time the shunt field picks up it will do so with the wrong polarity and the circuit-breaker will blow on closing *K* for charging the battery.

An inspector was called to a yacht to find the trouble with a gasoline-engine driven generator that would not generate. The voltmeter would not indicate when its circuit was opened and closed. Connected to a shaft extension at the commutator end of the generator was an air compressor for furnishing starting air. With the dynamo dead and the engine driving the compressor, there was considerable vibration. The inspector concluded that the dynamo, due to an ill judged closing of *K*, had received sufficient reverse current from the storage battery to greatly weaken the residual magnetism, and that the excessive vibration had "shaken the rest of the magnetism out." This reasoning seemed plausible, because upon lifting the dynamo brushes, so that the battery could not short-circuit through the armature, and closing *K* and giving the shunt field a charge from the battery, then opening *K*, replacing the brushes and starting the engine, the voltage came up promptly in the right direction.

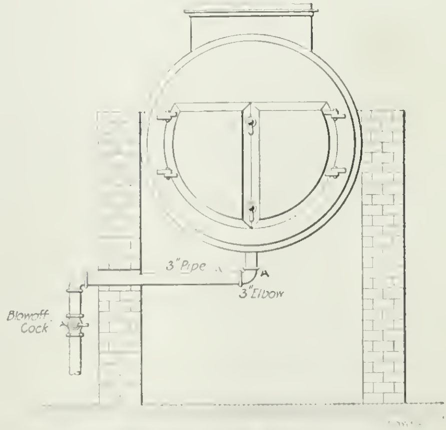
J. A. Horton.

Schenectady, N. Y.

⁂

A Case of Negligence

In a small Wisconsin manufacturing plant, where boiler inspection was none too rigid, the engineer noticed that an unusual quantity of feed water and fuel was used, but he investigated no further. When something went wrong with the blow-off cock, necessitating repairs, it was found in disconnecting the piping that a quarter of



Bad Thread on Blowoff

a turn completely disconnected the pipe at point *A* and the thread was almost completely eaten away. There was every sign of water having leaked there at a great rate.

It is surprising that the blowoff did not fail under pressure at this weak point. Such cases should emphasize the importance of thorough inspection.

CORNELIUS WEBER.

Milwaukee, Wis.

*

Coke as a File Brush

A piece of coke makes an excellent file cleaner. If it becomes full of grease when used on fine files, rub the coke on a rough file and it will become clean as well as clean the file.

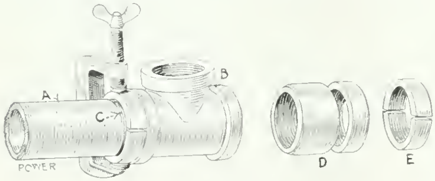
C. A. FORTNEY.

Lock, Penn.

*

Emergency Pipe Clamp

A satisfactory form of pipe clamp is here illustrated. Pipes and nipples generally first corrode through at the threads, because there the metal is thinnest. If the pipe is not screwed all the way into the fitting, this clamp may then be applied, no matter what the pressure is, and it will make a tight joint.



CLAMP IN POSITION

A represents a pipe screwed into fitting *B* and corroded at thread *C*. The clamp is made by sawing a ring off a coupling the size for the pipe, as at *D*; *E* is the ring sawed in two ready to put on. The width of the ring should be a little less than that of the thread outside the fitting. Say, if there are four threads outside, the ring should not be more than three threads wide. This will make a tight joint with a screw clamp, which is always handy in the engine room. Clamp the two half rings on the pipe with considerable pressure. If the thread on the pipe is clean, no packing is necessary except a little red or white lead. I always keep a number of these rings of different sizes on hand.

LOUIS KREUTZKAMP.

Brooklyn, N. Y.

*

Pump Regulators Commended

Many troubles, such as leaking feed lines, etc., are directly traceable to the practice of regulating the feed to the boilers by the speed of the feed pump.

The pump may be inefficient and regulating the speed by hand may cause the pressure in the feed line to be less than that in the boiler, consequently, if the checks should leak, the hotter water will back into the feed line, causing undue expansion strains as well as danger of water-hammer.

The remedy is to equip the pump with a governor, then, with a gage on the discharge line, the pressure can be so regulated as to have an excess pressure on the line at all times, regardless of the demand. After this, the condition of the check valve is of no consequence.

The amount of feed must then be regulated entirely by the position of the feed valve, allowing the governor to regulate the pump speed. I have known of cases where regulating the pump speed by hand has resulted in the pump becoming steam bound and causing a shutdown.

JOHN F. HURST.

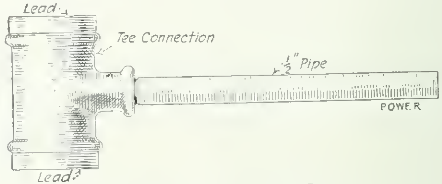
Louisville, Ky.

*

Handy Soft Hammer

Referring to the letter by J. C. Hawkins on p. 182, Aug. 4, a soft hammer may be easily made out of a pipe fitting, as shown in the illustration.

Use a Tee with a side opening into which a pipe is screwed for a handle. Plug the pipe and use a piece of cast iron or other scrap material for filling the greater part of the interior of the fitting, then cast the lead or babbitt metal so that there will be projecting faces at each end of the fitting.



FITTING FILLED WITH LEAD

A hammer of almost any weight may be made in this way and easily recast.

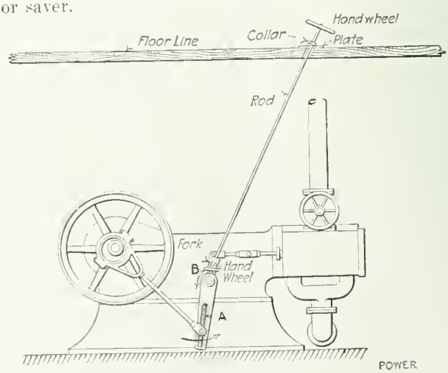
F. S. WILSON.

New York City.

*

Remote Control for Engine

The illustration shows a remote control for blower engines, which has been in use for several years, and is a labor saver.



HAND CONTROL ON CUTOFF

These engines, which are directly connected to 24-ft. fans beneath the firing floor, are equipped with regulating valves acting with the changes of pressure, but the extreme load variations made it necessary to secure a wide range of control.

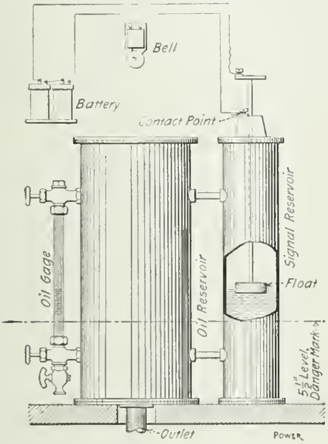
Changes in valve travel are secured by shifting the link block up or down in the rocker-arm by means of the screw *A*, and handwheel *B*. Formerly the water tender had to go downstairs to do this. Means were devised to operate the wheel from the floor above, as shown. The total cost did not exceed \$3 each.

Springfield, Ill. W. C. Cooper.

⁂

Oil Alarm on a Turbine

The Huron Cement Co., Alpena, Mich., of which the writer is chief engineer, has three times had trouble and been put to considerable expense through the damage to turbines from the splitting of a cooling tube allowing the oil to run from the reservoir into the sewer with the cooling water. As turbines are made today, there is nothing to show this danger until it is done, then it means new parts.



Low-Level Oil Alarm

To provide a warning before the mischief is done, the writer devised the oil alarm, shown in the accompanying sketch, the construction and action of which are self-explanatory. On the one side is a sight-glass indicating the level of the oil in the reservoir, and on the opposite side of the reservoir a metal cylinder connected similarly as a sight-glass containing a float on the top of the oil. A rod extending upward from this float is arranged to make an electrical contact when the oil level falls to the danger mark, and thus ring the alarm bell.

Alpena, Mich. T. S. North.

⁂

Formula for Self-Supporting Steel Stacks

The formula for the thickness of plate in self-supporting steel stacks, as presented by Mr. Durand, page 203 of the Aug. 11 issue, appears to give an unnecessarily great thickness of plate. The unit stresses of 6000 and 8000 lb. per sq.in. for single- and double-riveting, respectively, are, I believe, values of extreme conservatism.

Take a stack of 10-ft. diameter and 200-ft. total height, the bell of which is 25 ft. high; the formula for single-riveting gives a thickness of plate at the junction of shaft and bell of

$$\frac{175^2}{750 \times 60} = \tfrac{11}{16}\ \textit{in. nearly}$$

In the practical construction of self-supporting steel stacks, the thickness of the former is not over $\frac{1}{2}$ in. and the latter $\frac{3}{8}$ in. One company, extensive builders of self-supporting steel stacks, uses unit stresses for double-riveting as high as 11,000 lb. per sq.in. It would seem that with an ultimate strength of plate of 60,000 lb. per sq.in., a factor of safety of 4 and an efficiency of single-riveted joint of 55 per cent. an efficiency of double-riveted joint of 70 per cent. would satisfy all necessary requirements. This gives a unit stress for single riveting of 8250 lb and for double riveting, 10,500 lb. per sq.in.

The assumption of 25 lb. per sq.in. for wind pressure is evidently a typographical error which should have read "square feet."

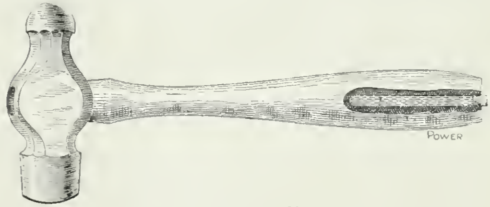
C. O. Sandstrom.

Kansas City, Mo.

⁂

Oil in Hammer Handles

Iron workers make a practice of drilling a hole about $1\frac{1}{4}$ in. in diameter and $2\frac{1}{2}$ to 3 in. deep into their hammer handles. The purpose of this is to fill the hole with oil in the belief that it prevents the handle from splitting and makes it more flexible. The illustration shows how it is done.



Oil in Hammer Handle

George J. Little.

Passaic, N. J.

⁂

Allowance for Expansion

I agree with L. Johnson, p. 179, Aug. 4, regarding keying up; even valves should be set while the engine is near the working heat. It is evident, however, that he has never had a large phosphor-bronze or gun-metal bearing run hot or he would have seen the engine slow down without the throttle being closed.

Prompt action is necessary in such cases to get it slacked back and the engine running again, thus avoiding a "freeze" and difficulty in making it leave the pin for refitting purposes. With the white-metal type of bearing, unless the engine is heavily loaded, there will be no slowing down as the metal will tear free and, if hot enough, it will throw out molten metal. In the case of a new bearing on an old pin, it will make a far better job by bedding itself by wear even if it runs a bit hot for a few days and loses a few gallons of oil.

Rochdale, England. E. R. Pryce

Engineers' Study Course

Elementary Mechanics--XXVIII

Last Lesson's Answers

126. The linear velocity of the point N when the wheel is running at 75 r.p.m. is equal to the circumference of a circle whose radius is 5 ft., times the r.p.m. Thus, the velocity of the point $N = 2 \times 3.1416 \times 5 \times 75 =$ 2356 ft. per min., or 39.3 ft. per sec. As this velocity was acquired in 2 min., or 120 sec., the gain in velocity in feet per second per second, or the acceleration, is

$$\frac{39.3}{120} = 0.327\ ft.$$

127. (a) In last week's lesson, it was shown that the gain in velocity in revolutions per second per second was equal to the linear acceleration a, divided by the radius times 2π. Thus,

$$A = \frac{a}{2 \times \pi \times R} = \frac{0.327}{2 \times 3.1416 \times 5} = 0.0104$$

which gives the acceleration in revolutions per second per second.

This acceleration might be found in another way. Thus, the revolutions per second $= \frac{75}{60} = 1.25$, and as it required 120 sec. to attain this speed, evidently the gain in revolutions per second per second must be $\frac{1.25}{120} =$ 0.0104.

(b) All points in the wheel have the same angular acceleration, as they all pass through the same number of radians per second.

128. The weight of the wheel is the same as that of a bar 8x10 in. in cross section, and of a length equal to the circumference of a circle whose diameter is equal to the mean or average diameter of the rim. As the outside of the wheel is 12 ft. in diameter, and the rim is 8 in. thick, it follows that the mean diameter of the rim is 11 ft. 4 in. The problem now resolves itself into finding the weight of a bar of cast iron 8x10 in. in cross section and 427¼ in. long (the circumference of the circle). The cubical contents of the bar equal $8 \times 10 \times 427.25$ $= 34.180$ cu.in., or $\frac{34,180}{1728} = 19.78$ cu.ft. The weight of a cubic foot of cast iron is 450 lb., hence the total weight of the rim is $19.78 \times 450 = 8900$ lb.

The radius of gyration is the distance from the center of the shaft to the center of the rim, or 5 ft. 8 in.

129. A speed of 90 r.p.m. = 1.5 rev. per sec. As this speed was attained in 1½ min., or 90 sec., the gain in speed was $\frac{1.5}{90} = 0.0166$ rev. per sec. per sec. In equation (77), it was shown that $P \times d = 2 \times \pi \times \frac{W}{g} \times R^2 \times A$, or, $P = \frac{2\pi W R^2 A}{g d}$. Now in this problem the weight W is 8900 lb.; the radius of gyration R is 5 ft. 8 in., or $\frac{17}{3}$ ft.; the angular acceleration A is 0.0166 rev. per sec. per sec.; $g = 32.16$, and the moment arm d is 2 ft. Hence, substituting these values in the above equations, there results,

$$P = \frac{2 \times 3.1416 \times 8900 \times 17 \times 17 \times 0.0166}{32.16 \times 2 \times 3 \times 3} = 463.4\ lb.$$

130. The reduction in speed is $(120 - 60) = 60$ r.p.m., or 1 rev. per sec. As this reduction takes place in 1 min., or 60 sec., the deceleration in revolutions per second per second $= \frac{1}{60}$. The braking force P required may be found from the same equation as used in the previous problem for finding the accelerating force; thus,

$P = \frac{2\pi \times W \times R^2 \times A}{g \times d}$, where $W = 8900$ lb.; $R =$ $\frac{17}{3}$ ft.; $A = 1/60$ and $d = 1.5$ ft., therefore,

$$P = \frac{2 \times 3.1416 \times 8900 \times 17 \times 17 \times 1}{32.16 \times 1.5 \times 3 \times 3 \times 60} = 620.4\ lb.$$

Centrifugal Force

Newton's first law of motion states that all bodies continue to move in a straight line except in so far as compelled by external forces to change that path. In order that a body may move in a circle, it becomes necessary to have some constraining force applied. If a flywheel breaks, it is a matter of common experience that the parts tend to move in straight lines because the motion is no longer constrained. What force, then, is necessary to keep an object moving in a circle?*

In Fig. 80, let the point A be rotating with a uniform linear velocity V about the point O. Now if the point A is to be kept moving in a circle, it must be evident that the link OA must exert a force sufficient to hold the point A in its path. This force is called the *centripetal force,* since it tends to draw the point A toward the center O with a definite acceleration. Likewise, the force

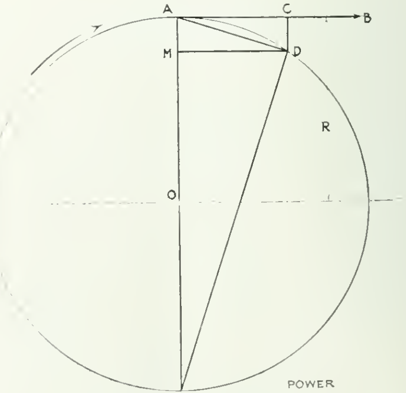


Fig. 80.

tending to draw the body A away from the center is called the *centrifugal force.* From the conditions of equilibrium, the centripetal and the centrifugal forces must be equal and opposite to each other. If the body A were free, it would move along the line AB, and at the end of a given time would be at some point C, but instead of being at C, due to the centripetal force, the point A rotates about the point O and reaches some point D on the circumference of the circle Connect the points A and D with a straight line. Now if the distance AD is very small, then the arc AD and the chord AD are practically equal. Draw the line DM at right angles to AE. The distance $DC = AM$ will then represent the amount that the point A is drawn out of the path AB.

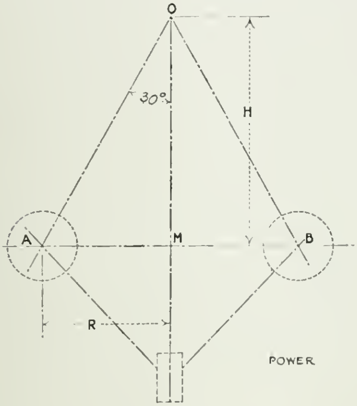


FIG. 81.

The distance AD represents the space passed over by the point A in a short interval of time, say t seconds, so that $AD = V \times t$. Now let a = the acceleration with which the point A is being drawn out of its path in a straight line. The distance AM will equal $\frac{1}{2} a \times t^2$ or $AM = \frac{1}{2} at^2$.

Draw the lines AE and DE. Then the triangles $ADMA$ and $AEDA$ will be similar, that is, they have their angles respectively equal, and as a result their sides will be proportional each to each. Thus,

$$\frac{AD}{AE} = \frac{AM}{AD}, \text{ or, } AD^2 = AM \times AE$$

From the above discussion, $AD = Vt$ and $AM = \frac{1}{2} at^2$, and as AE is the diameter of the circle, it must equal $2\ R$. Now, substituting these values in the above equation, there results

$$V^2\ t^2 = \tfrac{1}{2}\ at^2 \times 2 \times R, \text{ or}$$
$$V^2 = a \times R, \text{ and}$$
$$a = \frac{V^2}{R} \tag{78}$$

That is the acceleration with which the given point A is drawn out of its path in a straight line by the force acting in the link OA is $\frac{V^2}{R}$, and from equation (19) $F = \frac{W}{g} a$. Therefore, let C = the centripetal force exerted by the link OA to keep the point A moving at a distance R from the point O, then

$$C = \frac{W}{g} \times a = \frac{W \times V^2}{gR} \tag{79}$$

This same equation may be used to figure the centrifugal force exerted by rotating bodies. The existence of this force accounts for the fact that all large rotating bodies, such as flywheels, must be carefully balanced, otherwise there will be an excessive pressure exerted on the bearings supporting the rotating body. Likewise, the crank pins and part of the connecting-rods of engines must be balanced. This may be done in various ways. Where crank disks are used, one end is made much heavier than the other. In locomotives, additional weight is added on the side of the driver opposite to that containing the crankpin. This is called the counterweight or counterbalance.

Equation (79) may be expressed directly in terms of the revolutions per minute, N, made by the wheel. Since the linear velocity $V = \frac{2\pi RN}{60}$ feet per second, it follows that

$$C = \frac{WV^2}{gR} = \frac{W \times (2\pi)^2 \times R^2 \times N^2}{60^2 \times g \times R} = \frac{(2\pi)^2 WRN^2}{3600 \times g}$$

Or

$$C = 0.000341\ WRN^2 \tag{80}$$

STUDY QUESTIONS

131. A flywheel 10 ft. in diameter is running at 100 r.p.m Find the acceleration with which a point on the rim is moving toward the center of the wheel.

132. If the face of the wheel is 10 in. and the thickness of the rim 8 in., what is the centrifugal force per inch length of rim?

133. A wheel running at 1500 r.p.m. has an unbalanced weight of 5 lb. at a distance of 18 in. from the center. Find the pressure in pounds on the bearings due to this unbalanced weight.

134. Fig. 81 is a diagrammatic sketch of Fig. 14, Lesson IV. If the link OA is 18 in. long, find the r.p.m. of the ball A when the link makes an angle of 30 deg. with the vertical.

135. What decrease in speed must take place so that the angle OAM will be reduced to 20 deg.?

⁂

Longest Transmission Line

Officials of the Nevada-California Power Co. announce the completion of the company's transmission line from the plant of the Southern Sierra Power Co.

Power is now carried over the new line from the generating plant in the Sierra Nevada mountains near Bishop to El Centro in the Imperial Valley, a distance of more than 400 miles. This is the longest power line in the world being almost twice as long as the transmission line of the Pacific Light & Power Co., to Los Angeles. At the opening the new line carried 2000 hp. of electric energy. It has a capacity of 10,000 hp.

There are four substations on the new line, at Banning, Coachella, Caliptria, and El Centro and each of these will be a nucleus of a distributing system. There are four power plants in Imperial Valley, but these were unable to supply the demand and arrangements were made for a supply of power from Southern Sierra Power Co.

The greater part of the power transmission over the new line will be used for irrigation pumping. Underneath the Imperial Valley lie inexhaustible supplies of water, which must be pumped to the top of the ground to be available.

The Southern Sierra Power Co is controlled by the Nevada-California Power Co., and owns two hydro-electric plants, with a steam generating plant at San Bernardino. Its lines are connected with those of the Nevada-California Power Co., which owns a development of 35,000 hp., the two companies being operated as one.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We feel proud of the kind reception given our little daily, the "Power Pup," at the N. A. S. E. Milwaukee convention. Of course, its success was made possible only by the hearty support accorded it by both engineers and exhibitors. We thank them, one and all.

⁂

How a boiler manufacturer can find time to make boilers as well as jokes, let alone spread 'em broadcast (meaning the jokes) is beyond our ken. The twenty-sixth annual convention of the American Boiler Manufacturers did it at the Waldorf-Astoria, New York, recently. What else they did is something else again, but they're sure a happy lot, considering the nature of their business.

⁂

The motive power of an East Indian fan, the punkah, is the wallah, who operates it for $2.60 a month. But the enterprising Occidental is introducing the electric fan, putting the punk in the punkah and a wall around the wallah. This is what they call "palliating the fierce heat of the tropics."

⁂

Time approaches for the annual awarding of those forty-thousand-dollar Nobel prizes. While this is a neat little bunch of money, the attending publicity of the thing makes some of us modest uplifters hesitate.

⁂

No, sirree! not one word about the war. We are a neutral people, a peaceful country. Any more suggestions from our correspondent at Milwaukee and we'll refer him to Dick Foley, and—"Out the window he must go!"

⁂

President Wilson favors slicing twenty-five millions off the rivers and harbors appropriations. This slicing is evidently aimed, not at our water-power developments, but at Congressman Porkbarrel, who would make navigable his farm and those of his neighbors.

⁂

Somebody says that being a boy is a matter of temperament rather than age. Surroundings have something to do with it. We've known young men in archeological plants who looked like Pharaoh's granddad, and whiteheaded boys of fifty in a real plant who just radiated sunshine and kindliness; they'd make Sunny Jim look like a professional pallbearer.

⁂

MAN AS AN ELECTRIC CURRENT

BY F. W. SWIFT

Man can be compared to an Electric Current in many ways. He has to undergo a Series of Ups and Downs from the time he first enters this world until he leaves it.

If he has a large Capacity for directing his Energy in the right Line, he is going to be a Leading Power Factor in his community; if he allows himself to be Induced by others, he will be found Lagging.

He must get into Synchronism with his fellow workers—i.e., keep In Step with them when they are all directing their Energy for their employers' welfare. Personal Magnetism is the Exciter of the esteem and admiration of his employers and his fellows.

He must be able to Transform his Energy into whatever Phase of work he is, by circumstance, Transmitting, and so Distribute his Energy that his best service is obtained. His ability to overcome Resistances in his path depends upon the Pressure his mind and backbone exert.

The Frequency with which he studies Current affairs will show up sooner or later. Some men display much Reluctance toward the Admittance of new ideas into their Storage Cells and will not "Do it Electrically"; for such, a Ground!

His great Prime Mover is ambition. It Generates in him sufficient Power to do Watt he has to do, and his Efficiency is greatly augmented if he does not divert his Power in Generating Stray Current and—Exciting himself over small mishaps.

Electric Current is valuable for the work it does and the effects it produces, if it is available when needed. So also with man, who must be on the job in Readiness to Serve; if not, he will fall Flat at a quick Rate.

Care of Machinery and Tools

In visiting power plants, one sees little things that seem wrong, and perhaps similar ones in his own plant after returning.

For instance, bearing keys and wedges with battered ends look bad and sometimes cause trouble when the key is to be taken out; it could have been avoided if a soft hammer had been used. This also applies to Corliss-valve stem keys, which are frequently found battered. As a rule, small cylinder heads and valve bonnets have no eye-bolt holes, and in order to remove them it is necessary to use a chisel; this mars the edges. Eye-bolt holes should be provided, into which setscrews may be screwed to start the joint, and when the head is in place short nickel-plated capscrews may be put in the holes.

The square of the filling plug on the cylinder lubricators and the bonnets of brass valves are many times seen with the corners rounded off by using a pipe wrench or pliers to loosen them. Instead of a pipe wrench, use either a monkey wrench which will not spring, or an open-end wrench. If the plug leaks, put a lead gasket on the seat. While the first cost is a little more, lubricators should be nickel-plated, because they will always look clean if given a little attention and will not tarnish like the plain brass.

One frequently sees a wrench which is badly battered up from hammering on the end of the handle. Instead, why not slip a short piece of pipe on the handle? The nut can then be drawn up as tightly as desired. This, however, should not be overdone, or the bolt will be broken or the wrench ruined.

Another misused tool is the monkey wrench. It should not be used where a great strain is required, nor as a hammer. See that it fits the nut closely, and never use a pipe on its handle.

The Stilson and Trimo pipe wrenches are also much misused. Although they are made very heavy to withstand the hard usage, how many times we see them with the handles badly bent, showing that the size was too small or that there was a piece of pipe on the handle to give additional leverage.

Sometimes hand oil-can spouts are so badly battered that the oil squirts out at the side seam instead of at the end. Another eyesore is an overfull cylinder-oil pot setting on the engine or pump cylinder, the oil running down the side of the cylinder, presenting a slovenly appearance and being wasted. Greasy waste scattered about looks untidy, and is sometimes dangerous as it may catch fire or get into the machinery and cause trouble.

Every tool not in use should be cleaned up and put in its proper place, where it may be easily found when wanted. This, however, is not always done, and no one notices it sooner than the stranger.

These are some of the things which attract the attention of the visitor or the employer. Of course, they are not to be seen in our own plant, but anyone who visits around will notice them in the other man's plant. Perhaps it would be a good idea to look around tomorrow and see what you can find in those dark corners.

⁂

Weight and Bulk of Coal—The average weight of one cubic foot of solid coal is 87½ lb. The average weight of one cubic foot of heaped coal 51¾ lbs. One ton of coal occupies approximately 43½ cu.ft.

Uniform License and Boiler Laws

Several years ago, there was appointed by the Council of the American Society of Mechanical Engineers, in accordance with a resolution adopted at a regular meeting of that society, a committee to formulate standard specifications for the construction of steam boilers and other pressure vessels, and for the care of the same in service. John A. Stevens, consulting engineer, of Lowell, Mass., at that time a member of the Massachusetts Board of Boiler Rules, was selected as chairman, the remaining members of the committee being William H. Boehm, in charge of the boiler and flywheel departments of the Fidelity & Casualty Insurance Co.; Prof. R. C. Carpenter, of Sibley College; Richard Hammond, president of the Lake Erie Engineering Works; Dr. Charles L. Huston, vice-president and works manager of the Lukens Iron & Steel Co., and of the Jacobs-Shupert U. S. Fire Box Co.; E. D. Meier, past-president of the society and president of the Heine Safety Boiler Co., and Prof. E. F. Miller, of the Massachusetts Institute of Technology.

In February of this year, this committee issued a tentative report of 238 pages, comprising a suggested form of engineers' examination and license law, a boiler-inspection law and a code of rules for the construction and installation of boilers and other pressure vessels, for the use of the Boards of Boiler Control for which the suggested boiler inspection law calls. Some 1500 copies of this tentative report were issued to recognized authorities throughout the civilized world, including nonmembers of the society as well as members, and comprising boiler manufacturers, steel manufacturers, insurance companies, boiler users, consulting engineers, operating engineers and all who have special knowledge of the boiler business. Each was requested to study the report carefully and to give the committee the benefit of his knowledge, to the end that a model form of law and a code which would insure the best design, construction, installation and operation of steam boilers might be evolved through their collective wisdom and effort.

This report was briefly discussed at the St. Paul meeting of the society in June, and it was there voted that the committee should hold in the rooms of the American Society of Mechanical Engineers, 29 West 39th St., New York, a hearing of all interests concerned, on Tuesday, Sept. 15. The hearing thus provided for was called to order in the forenoon of Tuesday, Sept. 15, by Chairman Stevens, all of the members, with the exception of Col. Meier, being present. The occasion brought together between 100 and 200 engineers and manufacturers, boiler inspectors, officers of boiler insurance companies and others vitally interested in the questions involved.

HISTORY AND NECESSITY FOR UNIFORMITY

Mr. Stevens opened the meeting with a brief and forcible presentation of the history and necessity for the work which the committee has undertaken. In this country, since 1867, 46 years, there have been 10,051 people killed and 15,634 injured in boiler explosions which have found their way upon the records. In 1913, there were 499 explosions, with 180 killed and 369 seriously injured. The Massachusetts law was not brought into existence by the Brockton explosion, which cost 56 lives and $552,000, nor by the closely following Lynn explosion, but because the capitalists had something to say in Massachusetts. He had represented them upon the Massachusetts Board of Boiler Rules, and they insisted that they should have a set of rules which would avoid losses of this kind, and that they be uniformly enforced There were also thousands of operatives who put in their time over and around boilers. In Connecticut there was an explosion of a boiler, directly over which 50 girls had been working 20 minutes before. There is a boiler under one of the $1,000,000 hotels of New York which would not be tolerated within the confines of Massachusetts. For 10 to 20 per cent. additional cost, you can have boilers which are safe, and if you examine and certify the men who are put in charge of them, you will go a long way toward wiping out this blot on American industry, and of carrying out the idea of "Safety First" which has taken so strong a hold upon the people.

Edward H Wells, president of the Babcock & Wilcox Co., said that his company was in hearty accord with the effort which is being made to establish a standard specification for steam boilers. They believe in it, first, because they hope it may lead to the building of better and safer boilers; second, because they hope there may be established here a standard specification that shall be the pattern upon which 45 or 46 states which have not already acted shall base the laws which they are determined to pass governing the manufacture and use of steam boilers If out of the deliberations of this committee there shall come a set of specifications and rules for the building of boilers which may be incorporated into the laws of the states of the Union, every manufacturer of boilers and of material which enters into the construction of steam boilers will have gained a very considerable advantage.

WIDE INTEREST OF STATE LEGISLATORS

Thomas E. Durban, general manager of the Erie City Iron Works, said that the concerns which he represented have been interested in this subject for something like six years. They were driven into it from the fact that they manufacture all types of boilers, and are confronted with all kinds of laws in the various states. It is impossible to build a boiler which will conform with the laws of all the states and municipalities where it is likely to be used. This condition became so onerous to the builders of shell boilers that they had formed an organization for the purpose of advocating the adoption by the various states of uniform legislation, and, without knowing what the committee of the American Society of Mechanical Engineers was doing, had held several meetings, were in correspondence with the governors of 19 states who were awaiting only the completion of a standard form of law to recommend it for passage by their legislatures. When the work of this committee came out in the spring, they fell into hearty accord with it, and were now awaiting only their final report to adopt it as a basis of their promulgation work. There never was a more propitious time to urge the passage of such legislation, and there is no better subject for legislation to put before the legislators. In our factories, we are obliged to protect the gears, we have to protect the elevators, all the buildings must have fire-escapes in order to meet the requirements of the Safety-First movement, yet, as Mr. Stevens has pointed out, it is possible now, in many of the states where this Safety-First movement has been working, for a man to put up an elegant building provided with every possible safety device, and yet to have in the basement of that building a boiler that may devastate the entire structure. The boiler manufacturers recognize their responsibility in the matter. It means a radical change in the process of manufacture to a great many people, and yet among all the boiler-making fraternity he did not believe there was a single man who had objected to the movement. But uniformity is an absolute necessity in putting work through the shop. If it has to meet the requirements of an Ohio law, an Indiana law, a New York law and a Pennsylvania law, that differ in one simple detail, it is almost impossible, with the variety of boilers and the different types of boilers, to put them through the shop and have them come out right. There is also to be considered the man who is in an occupation, as, for instance, a building contractor who has different engines for each state in which he makes a contract. The agricultural-engine people who build their boilers for threshing purposes will have to have a different boiler for different states. It not only makes it inconvenient for the manufacturers, but it is a needless waste of money to the purchaser. The boiler makers stand here willing to accept anything that is right, regardless of small technicalities, so long as we can get uniformity. The time is ripe for this kind of legislation. We must not put it off. If we can make a recommendation close to the existing laws, and if we can get five states, or even three states, of prominence to adopt the recommendations of this society, it will be a perfectly natural outcome that the other states will do the same thing.

Mr. Connolly, of Cleveland, said that the American Boiler Manufacturers' Association, representing about 90 boiler manufacturers, has in view the same thing that Mr. Stevens and Messrs. Wells and Durban have urged, the protection of life and property. The three essentials to this are good materials, good workmanship and an operator who understands the operating of a steam plant. He would like to see the rules as concise as possible, and recommended that particular attention be paid to the phraseology, so that there need not be developed a lot of boiler lawyers to tell what the law means after it is passed.

Mr Broderick also spoke for the American Boiler Manufacturers' Association, putting in a strong plea for a uniform law. He came from Indiana, and said that that state had the poorest boiler law of any in the union.*

C. S. Blake, secretary of the Hartford Steam Boiler Inspection & Insurance Co., said that his company has always advocated proper laws regarding the licensing of engineers and the construction of boilers. It was influential in framing the Philadelphia ordinance, nearly 50 years old, and has always been glad to give its help and advice to states and municipalities in framing laws. Any position contrary to that would be in contradiction to the claim which they have always made of being the first company to insure safety.

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*See "The Indiana Boiler Law," in the issue of Aug. 25, page 277

N. A. S. E. READY TO COÖPERATE

Joseph Carney, superintendent of the McAlpin Hotel, and representing at the hearing the National Association of Stationary Engineers, of which he is a past-president, spoke from the point of view of the users of boilers. He said that he was deputized by that society to convey to the committee its deep interest in the work which they had undertaken, and its readiness to coöperate to the full In introducing Mr. Carney, as well as during the previous discussion of the tentative report at the St. Paul meeting, Mr. Stevens gave the National Association of Stationary Engineers very complimentary credit for the persistent effort which that association had made, almost single-handed, for license and boiler inspection laws, and Mr. Carney, in acknowledging this compliment, expressed the pleasure of the body which he represented to find that the great American Society of Mechanical Engineers at work on the same line that they had pursued in their crude way for so many years, and trusted that much good would result. Past National President James Coe spoke also for the State Association. Dr. Alexander C. Humphrey, past-president of the society and president of the Stevens Institute of Technology, advised the committee against undue haste, and reminded them that any act of theirs would be accepted as an act of the society. He said that there were important interests which had not been consulted, and hoped that every available source of information would be sought, and everybody whose interest was affected would be permitted to have a say before the report of the committee was finally put before the society.

E. T. Child, representing the Association of Master Steam and Hot-Water Fitters, assured the committee of the hearty sympathy of that society with its efforts.

LIGHTING AND TRACTION INTERESTS URGE UNIFORMITY

I. E. Moultrop, of the Edison Electric Co., of Boston, said that the interest with which he is connected uses a large proportion of the boilers in use in this country, and it would be a great benefit to them, as boiler users, to have a standard to which all boiler manufacturers should live up. Anything that this committee could do to bring about that condition would be of real benefit, but they ought not to push it through too rapidly and subject themselves to the criticism that all interests had not been heard. He suggested that the Association of the Edison companies, the National Electric Light Association, the American Street Railway Association and the railroad organizations ought to have a hand in the matter.

Edwin D. Katte, chief engineer of electric traction, New York Central & Hudson River R.R., and chairman of the committee on railroads of the American Society, assured the committee that the railroads were among the largest users, even of stationary boilers, and that his committee had much to impress upon them if they were afforded the opportunity.

Edgar Marburg, secretary of the American Society for Testing Materials, made a persistent effort to get himself and the representatives of his society upon the committee as voting members. They would not give the committee the benefit of their knowledge of the subject upon any other condition. They refused to be put up as witnesses to be cross-examined, and without the privilege of bringing in a minority report, but insisted upon sitting upon the bench. His insistence upon this point, with the intimation that others might insist upon a like representation, created some confusion in the forenoon session. At the commencement of the afternoon session, however, the committee announced its intention to hear everybody who had sent in a written discussion first, persons who had not presented a written discussion directly after, or at a hearing to be arranged later; that another public hearing or hearings should be held, if the results of this hearing demonstrate the need thereof, and that the committee would meet in conference with any interested body and give the representatives of that body opportunities for full discussion and consideration of every question involved by the report. Proceeding in this line, the committee succeeded in reconciling its differences with the steel manufacturers, the railroad and the other interests, and avoided a criticism of not having had the coöperation of the American Society for Testing Materials by adopting the code of that society, with a few unimportant modifications, so that as the hearing adjourned, there appeared to be a substantial agreement upon a code which will insure, as the chairman expressed it, a little better material than we have been accustomed to having, correctly designed, honestly constructed and properly operated boilers, and a material reduction in the number of accidents resulting from their misuse.

POINTS RAISED FOR CONSIDERATION

Some of the points raised for consideration were:

The possibility of making the engineers' license universal by providing that the license of one state should be accepted in another when approved by the inspector of the latter state.

Instead of exempting locomotive boilers generally, exempt only those which are under the jurisdiction of the United States Government. This would bring under state inspection the locomotives of private companies, and drill engines, etc., used by the railroads; everything, in fact, not inspected by the Federal authorities.

What about locomotive cranes and pile drivers, and dismantled locomotives used in stationary service? Should the age of such boilers, as affecting the factor of safety, be reckoned from the date when they were first made, or the date when they became stationary boilers, in view of the fact that they are at that time largely made over?

Should boilers built for shipment out of the state be exempt from inspection while building, which is the only chance to observe compliance with the rules? If inspected during construction, should the inspection be by the state in which they are built, or by the state into which they are going? If the latter, what about stock boilers, portable boilers and boilers having no definite destination?

The tentative rules provide that every insurance company authorized to inspect and insure boilers and pressure vessels shall have in its employ at least one inspector who resides in the state. Mr. Blake pointed out that the total business of all the companies insuring boilers did not amount to enough in states like Idaho, Wyoming, etc., to support a resident inspector. It would affect his company less than the smaller companies, but it was unjust to all. The tentative rules provide that inspectors of boiler-insurance companies shall be examined by a board consisting of three members of the State Boiler Department. These are drawn from the same rank and plane, with the same degree of education, as the candidate. Mr. Blake thought that it would be better to provide a board with greater experience in examinations, and in gaging and testing men for competency. In Ohio they had improved upon the Massachusetts law by requiring a written examination. Mr. Blake further pointed out that the Massachusetts rules provide that if a man retires voluntarily from the service of one company, he cannot serve as inspector for another until he takes a new examination. On the other hand, the rules provide that a man cannot take another examination inside of 90 days. Two years ago, one of the companies operating in Massachusetts went out of the boiler business, and their inspector, who had passed his examination shortly before, was out of a job for three months. A man once licensed should always be licensed.

It was suggested that the serial number applied by the boiler manufacturer to the boiler when made should be accepted by all the states that the boiler may be used in, and that a boiler inspected and passed in one state should be adjudged good in another.

A suggestion was made that fusible plugs be required to be filled with pure Banca tin, instead of the "pure" tin of the committee's suggestion. The railroad men were in favor of doing away with the fusible plug altogether, the marine men were strong for it, and most of the stationary men preferred that it should be required. It was pointed out that tin from the island of Banca is no longer procurable in large quantities, and that the degree of purity implied by the committee's suggestion might be called into question. The best suggestion made was that the melting point be specified. Mr. Olshausen, of the Bureau of Standards, suggested that there was such a thing as tin disease; the metal changed its nature and its melting point; and he suggested that the whole subject be referred to the Bureau of Standards.

The provision for putting the law into operation should be such as to adapt itself to states in which there is already some sort of inspection; otherwise, political and other opposition may be incited. The legal part of the document is largely paraphrased from the Massachusetts law, and it will be necessary to have this portion of the report reviewed by a lawyer before it is finally presented.

Prof. Gaetano Lanza, of the Baldwin Locomotive Works, pointed out that the rule for the maximum allowable pressure, which in the report is the formula ordinarily in use, attempts to determine the strength of the weakest plate by coupling with the diameter of one plate the thickness of another. The strength of each plate should be based upon its own diameter and its own thickness.

LOWEST FACTOR OF SAFETY

In the tentative report, the lowest factor of safety to be used for boilers, the longitudinal points of which are of butt and double-strap construction, is 4.5. Prof. Lanza says that the use of a factor of safety of 4 has been and is very widespread, and has been adopted by many authorities which prescribe laws for the construction of boilers, including the Interstate Commerce Commission in America and a number of boards in England. Seaton, on page 443 of his treatise on Marine Engineering, edition of 1907, says:

"The board requires a minimum factor of safety of 4.5, while the Admiralty is content with 4, which is quite sufficient, considering the stress on the material is gently applied and quite a steady one during work." The size of safety valve required should be based on the amount of heating surface instead of the grate area. In the light of a series of experiments made, a committee of the Railway Master Mechanics Association decided that in order to relieve the boiler, the discharge of the safety valve should be 4.1 lb. of steam per hr. per sq.ft. of heating surface.

SHEARING STRENGTH

The results of such experiments as he, Prof. Lanza, had in mind would lead him to place the shearing strength of steel rivets in single shear at about 44,000 or 45,000. The Interstate Commerce Commission advocates 44,000, and many bodies which make rules for boiler construction prescribe 44,000 or 45,000. He was not aware of any experimental evidence that would warrant the use of a smaller value of shearing strength in double shear than in single shear, meaning by this that a rivet in double shear ought to be credited with both sections sheared or have a value of twice the single shear.

BOILER RATINGS

The tentative rules provide that a boiler having 1 sq.ft. of grate surface shall be rated at 3 hp., when the safety valve is set to blow at over 15 lb. per sq.in., and a boiler having 2 sq.ft. of grate surface shall be rated at 3 hp. when the safety valve is set to blow at 15 lb. per sq.in. or less, evidently meaning that such boilers ought to be rated with the respective amounts of horsepower for each one or two square feet of grate surface. Prof. Lanza pointed out that this was not in accord with the standard adopted many years ago by the American Society of Mechanical Engineers.

The moment of inertia of an angle or a "T" is not correctly expressed by the formula $\frac{bh^2}{12}$.

In calculating the area to be stayed in such surfaces as the heads of horizontal return-tubular boilers, an arbitrary allowance of 3 in. from the flange is not suitable for all cases; sometimes more and sometimes less would be proper.

C. D. Young, testing engineer for the Pennsylvania R.R., did not believe a minimum factor of safety of 4.5 proper for all cases of stationary boilers. There should be some variation in the factor of safety, depending upon the service, pressure and maintenance to which the boiler has been subjected. He did not believe that any definite proof could be shown, where any boiler had exploded because it had a factor of safety as low as 4. When the diameter of the rivet holes in the longitudinal seam of a boiler is not known, one of the rivets should be removed in order to measure the diameter of the hole, and if impossible to fill the hole with a new rivet, the hole should be tapped and a tap bolt applied. In his opinion, the size of safety valve should be based on the heating surface.

S. F. Jeter said that in Massachusetts the factor of safety incorporated in the proposed rules was adopted five, six or seven years ago. In that state, conditions were different from those in the United States generally. The boilers were operating under a high factor of safety, and pressures were somewhat conservative. The majority of the boilers in the United States are now operating on a factor of safety of something over 4, and many on a factor of 4, and, if you attempt to apply a greater factor to boilers already in use you are going to meet tremendous opposition from the owner. The adoption of a factor of safety of 5.5 would seriously affect probably 60 to 75 per cent. of the boilers in use, and he believes it will be absolutely impossible to enforce such a law. The Ohio law is much superior to Massachusetts in this respect.

C. D. Young said that the ultimate allowable shearing strength for iron rivets in double shear should be double that for single shear, or 76,000 lb. per sq.in., as corroborated by recent tests on rivets in single and double shear. The proposed law provides for steel rivets to have a strength in single shear of 42,000 lb. and in double shear of 78,000 lb. He believes these figures should be raised to 44,000 and 88,000 lb., respectively. He has a record of a large number of tests made under his jurisdiction in the test department of the Pennsylvania R.R., which shows that steel will give a shearing strength above the figures quoted. The Federal Government has recognized these figures in the maximum shearing strength, under the regulation of the Interstate Commerce Commission.

The clause relating to maximum pressure should be worded to permit the use of cast iron for malleable headers if superheated steam is used, as it is good practice for pressures above 125 lb. He has had a great deal of experience with cast-iron superheater headers used on pressures as high as 205 lb., and found them entirely satisfactory. The character of the superheater header cannot in any way be a dangerous element to the operation of a boiler. C. A. Anstrom favored extending the life of lap seam return-tubular boilers to 25 years.

Mr. Kruesi, of the General Electric Co., objected to the age limit specified in the rules for factors of safety, as it would put out of commission many boilers in good condition.

Mr. Young objected to the sliding scale for factors of safety. To boilers properly maintained, the sliding scale need not apply, and under such conditions the age should not increase the factor of safety required. Mr. Boehm, of the committee, asked: "Suppose a boiler has a weak head, and it had been breathing more than usual and fatigue had taken place? Would you not discuss a factor of safety then?" Mr. Young replied that if the committee had any evidence to indicate that any trouble had occurred, this might be done, but to make the rule cover all cases where the design has been proper and the maintenance good did not seem necessary.

POP SAFETY VALVES

A. J. Schoff objected to the rule requiring pop safety valves, and suggested that the lever safety valve be allowed. He said that they have 300 of them, which have beeen used for 30 years. The government made them put a pop safety valve on one; they had all kinds of trouble and had to go back to the government and get it changed back to a lever valve.

A. D. Carhart, superintendent of the Crosby Steam Gage & Valve Co., thought that Mr. Schoff gave an erroneous impression in making it appear that lever safety valves are superior to the pop type. The government had limited experience, and it continued the use of lever valves, but did not allow them on new installations. He thought it a hardship to require two safety valves on all boilers. It was a good thing, but might be a hardship on small boilers under 15 lb. pressure. When a boiler requires a valve less than $2\frac{1}{2}$ in. in diameter, it would be too bad to make them split it into two valves. In the case of valves of larger diameter, it is all right, and is less strain on the boiler. He thought that the heating surface instead of the grate surface was the logical factor for determining the area of the safety valve, but had withdrawn his active advocacy of that practice because of the number of advantages and workable features of a proper rule based on the grate surface.

L. M. Brigham, of the Consolidated Safety Valve Co., objected to the general formula for a safety valve proposed by the committee, because it does not take into account the lift of the valve, and suggested an entire modification of the safety valve requirements. F. C. Blanchard, speaking for Mr. Brigham, said that their company and other leading safety-valve manufacturing companies had made tests of valves from different manufacturers; the lifts are found to vary in the neighborhood of 300 per cent., some having three times the lift of others of the same diameter and built by the same concern. The proposed rule and the Massachusetts and other rules assume that the lift must be $\frac{1}{32}$ of the valve diameter; in other words, a valve 4 in. in diameter is assumed to have a lift of $\frac{1}{8}$ in. to pass the steam which the rules specify. There are velves on the market that will not do that. He believes this is an opportunity for the board to make a rule which is logical, and to base it on the evaporation and the actual valve capacity. The Master Mechanics Association, representing the railroads of the country, made a rule two years ago in which it took the lift into account. He recommended that the accumulation test be made a portion of the rule. It consists in shutting off all possible exits of steam. The boiler is then run to its full capacity, and if the pressure in the boiler runs up 15 per cent. over the pressure for which the safety-valve equipment is set, it is considered inadequate.

Mr. Crosby said that we have a million boilers probably in this country, and if you undertake to tell them all to put on two safety valves there will be trouble.

Prof. Jacobus called attention to the fact that there were a number of boilers, such as waste-heat and other types, which do not have any grates at all upon which the size of the safety valve could be based. There are a number of boilers in the city which are run from 300 to 400 per cent. of rating. There you must have provision for taking care of an enormous amount of steam in case of a sudden shutdown of the engine. As far as he knew, the only way to get at it was to know the maximum steam-making capacity of the boiler, and provide safety-valve capacity to take care of it.

Prof. Miller, of the committee, said that they had been holding back on the safety-valve question, thinking that the research committee on safety valves which the society had in the field would be able to report in time for this committee to use the information. Such things as having the safety valves marked with the discharge capacity have been considered. A valve with a high discharge opening may give a hard, pounding action when the valve seats. He thought the best satisfaction came from the use of valves with small lifts. Unless the lift of the valve is marked upon it, it would be impossible to tell the discharge capacity, and even then the resetting of the valve by the engineer may alter the lift or discharge capacity quite a little.

Mr. Blake said that Philadelphia has for many years required two safety valves on all boilers installed within its jurisdiction.

Mr. Carhart urged that the safety valve be directly upon the boiler, and not upon a connection.

Prof. Jacobus said that safety valves should be placed on the outlet of superheaters, and not on the inlet, the idea being that if the flow of steam is suddenly checked the superheater becomes filled with steam not in contact with water, and there is nothing to limit the temperature to which the steam may be carried. If the safety valve is on the outlet of the heater, the application of heat will raise the pressure, the safety valve will blow, and the temperature cut down within safe limits.*

Mr. Stevens explained that the rule was made to protect the safety valve. At the inlet it would be subjected only to saturated steam, and under all conditions of temperature would be in active order. Prof. Jacobus said that he would put a valve on the outlet and omit it on the inlet, but have it designed to stand superheated steam with an outside spring. Mr. Carhart, being a maker of pop valves, raised a laugh by recommending that valves be used on both inlet and outlet. Prof. Jacobus said that it would be hard in some constructions to get a safety valve on the inlet of the superheater, and so far as the idea of having a superheater explode from the pressure due to a slug of water, he had tried the experiment a number of times, and the amount of back pressure to be got in that way is not dangerous.

The chairman asked if this would apply to independently fired superheaters, and Prof. Jacobus replied that the two valves would be all right there. On an independently fired superheater, it would be well to have them on the inlet and outlet, but on the outside only on the connected superheater

Mr. R. D. Yarnell recommended that nonreturn valves be used in every boiler installation.

CHEMICAL LIMITS OF BOILER STEEL

The tentative rules of the committee gave as the chemical limits of the steel to be used in boiler construction manganese, 0.30 to 0.50 per cent.; phosphorus, 0.03 per cent. maximum; sulphur, 0.03 per cent. maximum. These figures were vigorously combatted by the steel manufacturers, with the result that they were modified to 0.035 per cent. maximum so far as the phosphorus and sulphur are concerned. All firebox steel is to have a tensile strength between 55,000 and 63,000 lb., but to be stamped 55,000, and both firebox and flange grades may be used.

Conferences were held with the steel manufacturers, tube manufacturers, and the draft of rules revised, as above stated, and so as to allow charcoal iron and lap welded tubes. We may discuss some of the provisions further in a later issue.

* * *

Salmon River Development to be Enlarged—Organized chiefly by Spokane, Wash., contractors, the Salmon River Light & Power Co. has sold bonds in the amount of $125,000 to the Spokane & Eastern Trust Co., and is starting plans for the enlargement of the hydro-electric development of the Salmon river in Lemhi County, Idaho. The trust company has already resold $1[illegible],00[illegible] the bonds to Spokane investors. The issue is in [illegible] year serial bonds bearing 6 per cent. interest. The company was recently incorporated and has taken over the Lemhi Power Co. which was successfully operated for several years, supplying light and power to the town of Salmon Idaho. The new corporation will start at once the construction of a new power plant, including a dam across the Salmon River, designed to have a capacity of 3000 hp.

Some Features of the Electrical Exposition and Motor Show

For the purpose of showing how important a part electricity plays in modern warfare, the army and navy of the United States are arranging a series of special exhibits to be included in the Electrical Exposition and Motor Show to be held in New York City, the second week in October.

One of these exhibits will show the use of electricity in coast defense service. It will embrace the mining of harbors, handling of big guns, signal devices and lines of communication, the use of search lights, etc., in all of which electricity plays a more or less important part. One of the navy exhibits will be the bridge of a battleship, complete in every detail, showing how electricity is used to control the great fighting ships. How electricity is employed in submarines and the new electric cooking range for warships, also to be shown in action, are other features of the navy exhibit.

A small arsenal, fully equipped and engaged in making ammunition, is to be exhibited by the ordnance department of the United States Army. The chief of this department, Brigadier General Crozier, is taking personal charge of the preparation and display of this exhibit. The electrically operated machinery and the officers and men who will use it in making ammunition at the Electrical Exposition and Motor Show, will come from the Frankfort Arsenal at Philadelphia.

However, most of the one hundred and fifty exhibits already arranged are devoted to a more peaceful use of electricity, to its constructive rather than its destructive employment. The Government also participates in this phase of the exposition, for a United States mint, actually in operation making real money, is to be shown under the supervision of the director of the Mint.

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Warn Minor Employees—An employer may be found to have been negligent in permitting an inexperienced employee 18 years old to assist in tying high-voltage wires without instructing him concerning the dangers incident to such work. (United States Circuit Court of Appeals, Ninth Circuit; Betts vs. Bisher; 212 "Federal Reporter," 581.)

Discrimination by Water Companies—A water company which illegally discriminates against one consumer by allowing another a lower rate than is charged the former cannot be compelled to allow the former the lower rate. The only remedy is to compel the company to raise the rate improperly allowed the latter consumer. (South Carolina Supreme Court, Paris Mountain Water Co. vs. Camperdown Mills, 82 "Southeastern Reporter" 417.)

New York's Sunday Law—The Erie County Court in a recent opinion upholds the validity of the law enacted by the New York legislature in 1913, which requires employers in certain industries to allow their employees at least twenty-four consecutive hours rest in every seven days, except that employees may be engaged not more than three hours on Sunday in repairing boilers and machinery, and in other specified occupations which are necessary, including keeping up fires.

Idaho Public Utilities Act Valid—In a proceeding recently brought by the Idaho Power & Light Co. and the Beaver River Power Co. against the Idaho Public Utilities Commission, the Supreme Court of that state upholds the validity of the provision of the Public Utilities Act of 1913 which requires a power company to obtain a certificate of necessity and convenience from the Commission before constructing works in territory served by a competing company.

Risks Not Assumed by Stationary Engineer—In recently affirming judgment in favor of a stationary engineer, against his employer, for injury received when his overalls came in contact with a revolving setscrew on a line shaft, the Arkansas Supreme Court held that such employees do not assume the risk of being injured through the existence of defects negligently permitted by the employer to exist, unless the employee discovers the danger. In this connection, it is to be remembered that in several states there are now in force laws requiring setscrews to be safeguarded, and it is uniformly held by the courts that under such laws an employee does not assume the risk flowing from his employer's failure to comply with the law, whether the employee knows the condition of the setscrew or not.

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*See "Power," Jan. 27, 1914, pp. 130-132.

Subordination of Water Power Rights—The rights of one who owns land along a river, and who maintains a dam therein for the development of power, are subordinate to the right of the state to control the stream for navigation purposes. And the state may so far delegate its power in this respect as to authorize a logging boom company to maintain works in a stream and its tributaries to promote floating of logs. In exercising this authority, the boom company will not become liable to one whose water power rights are thus impaired, unless the injury is unreasonable and unnecessary. This decision has just been handed down by the Minnesota Supreme Court in a case involving the liability of a boom company for interfering with a mill owner's rights.

Employer's Liability for Defective Engine—An owner of a power plant is not responsible for injury to an experienced engineer, resulting from unexpected starting of the engine, caused by a leak in a valve, if the employer was not chargeable with notice of the existence of the defect. (Alabama Supreme Court, W. R. Flowers Lumber Co. vs. Hutchins, 66 "Southern Reporter," 108.) In this case the injury occurred while the engineer was stooping over the engine, tightening brasses. The Supreme Court further holds that in such a case the burden is on the engineer to show the existence of a defect directly causing his injury and negligence on the part of the employer in permitting the defect to exist.

Storage of Gasoline as Nuisance—Although storage of gasoline on premises adjacent to or adjoining the premises of another does not constitute a nuisance in itself, so far as concerns the rights of the adjoining owner, the Michigan Supreme Court holds in the recent case of Whittemore vs. Baxter Laundry Company, 148 "Northwestern Reporter" 437, that the storage may become a private nuisance, considering the particular locality, the quantity, and the surrounding circumstances, regardless of the degree of care used in keeping the gasoline. In this case the court decided that maintenance of two steel tanks under ground for the storage of 20,000 gal. of gasoline, within a few feet of a nearby dwelling house, would constitute a nuisance, as against the owner of the house, and, therefore, an injunction was granted against such storage.

Electric Power Contract Construed—Under an agreement by an electric power company to furnish a current not exceeding 300 electric horsepower, the company cannot be required to furnish three or four times that amount to start motors, although the contract was made with reference to use of the current for that purpose; the necessity for the use of a large additional current for starting purposes not having been foreseen by either party at the time the contract was entered into. (United States Circuit Court of Appeals, Ninth Circuit; Alaska Treadwell Gold Mining Co. vs. Alaska Gastineau Mining Co, 214 "Federal Reporter," 718.) The type of motor involved in this case was the "General Electric Form K," which was found by the court to require at least three or four times the starting surge it requires to operate its load. The Court of Appeals says: "It is manifest that whether the starting surge is needed 10 sec. or 30 sec., or only one second, if the contract requires appellants to furnish it, they are obliged to have it constantly available for the appellee's use, and therefore cannot divert it to other uses without liability for damages. To read by construction into the written contract of the parties, such a requirement is therefore to read into it a most important provision not there found."

Warranty of Power of Engines Sold—When an engine is sold under a warranty by the seller that it will develop a certain horsepower, is the representation to be deemed to apply to gross power, or to net power, when geared to machinery? This interesting question was recently propounded to the Indiana Supreme Court, in the case of Winnemucca Water & Light Co. vs. Model Gas Engine Works, 101 "Northeastern Reporter," 1007. The court decided that, if the contract of sale or the surrounding circumstances do not show that it was otherwise contemplated, the warranty will be declared to apply to gross power. The contract in this case was for the sale of a gasoline, distillate, alcohol engine, "Horsepower developed at 275 r.p.m. 150 actual hp.," and contained a warranty that the engine would develop its "full rated horsepower." The court found that it was a custom in the trade to reckon the gross, and not the net, horsepower in supplying engines of a rated power, and that 40 per cent. of the rated power is the average loss from friction. The judge who announced the opinion said: "Under the tests as made, about 9 per cent. was computed for inefficiency in the generation, and in addition a 36-in. waterwheel was geared to the shaft, the percentage of reduction of power to move which is not shown, and the tests were not made by a reasonable method, so that it is impossible from the evidence to determine what power was actually developed by the engine when geared to machinery." The court concluded that, in the absence of any representation by the seller as to what net power would be developed by the engine, or notice of the net power required for the buyer's purposes, or of any representation inducing the buyer to believe that he was obtaining 150 hp. net, he had no cause of action against the seller for insufficiency of the engine in this respect.

International Association's Peoria Convention

The fourth biennial convention of the International Association of Steam and Operating Engineers was held at Peoria, Ill., during the week beginning Sept. 14. The Fey Hotel was the headquarters. There were about 200 delegates present from all parts of the United States and Canada.

The several business sessions of the delegates were held in the hall of the Knights of Columbus, conveniently situated to the headquarters. The spacious skating rink adjoining Columbus Hall was tastefully decorated and neatly arranged for the various supply houses in the display of their power-house equipment.

On Monday morning, at 11 o'clock, the opening exercises of the convention took place. Oscar Moore, chairman of the local committee, occupied the chair, and after a brief speech, he introduced Edward N. Woodruff, mayor of Peoria, who, in a kindly address, welcomed the delegates and their friends to the city. Walter S. Bush, secretary of the Trade and Labor Association, was then introduced and spoke interestingly on subjects of interest to the engineers. Matt Cummerford responded fittingly for the engineers. The meeting then went into executive session. After the appointing of the necessary committees, an adjournment was taken until 2 o'clock.

There were many features of entertainment, including shopping trips for the ladies, automobile rides through the city and visits to many of the large plants. On Monday evening, the delegates and their gentlemen friends enjoyed a smoker in the exhibition hall. Wednesday night there was a moonlight ride on the Illinois River, which was greatly enjoyed. Thursday evening, the convention journeyed to Prospect Heights and partook of a hearty supper at "Ye Olde Tavern."

Among the important business measures of the convention was the endorsement of a life insurance policy, and also the buying of property for locating permanent headquarters at Chicago.

A ladies' auxiliary was organized on Thursday, and the following international officers were elected: Mrs. George P. Amedee, Oakland, Calif., president; Mrs. Flora L. Beckwith, Spokane, Wash., vice-president; Mrs. Mary Burt, Palmer Park, Ill., secretary-treasurer; Mrs. Lilly Roberts, Oakland, Calif., general organizer; Mrs. Elizabeth Lewis, Mrs. Sarah Welton and Mrs. Daisy Kasper, trustees. This independent organization received the hearty approval of the main body.

There were upward of 30 booths on display in the exhibit hall, among them being many of the leading firms.

The present policy of the organization was indorsed by the re-election of the entire administration ticket, as follows. Matt Commerford, St. Paul, Minn., president; Milton Snellings, Washington, D. C., first vice-president; T. J. Roberts, Oakland, Calif., second vice-president. Michael Kelly, New York, third vice-president; Michael Murphy, New York, fourth vice-president; Will M. Finlay, Toronto, Can., fifth vice-president; James G. Hannahan, Chicago, secretary-treasurer; John L. McNamara, John W. Maher and P. J. Gorman, trustees.

The next biennial meeting will be held in Newark, N. J., in September, 1916.

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Facts About Coke—The loss of combustible matter in converting coal into coke is from 33 to 40 per cent. The heating value of a pound of coke is approximately the same as coal. The average weight of heaped coal is 30 lb. per cubic foot. One ton of coke occupies 70 to 75 cu.ft.

NEW PUBLICATIONS

POWER AND POWER TRANSMISSION. By E. W. Kerr, Professor of Mechanical Engineering, Louisiana State University. Published by John Wiley & Sons, New York. Size 6x9 in.; 391 pages, 325 illustrations; third edition, thoroughly revised. Cloth. Price, $2.

From the pretentious table of contents, one would expect to find a store of valuable engineering information in this book, but some of the subjects are treated in a most perfunctory manner and the entire work is surprisingly superficial, composed as it is of short extracts from works on physics, etc., and copious quotations from trade catalogs.

Several errors in makeup are noticeable even on casual reading; for example, Fig. 244 is inverted in position. Fig. 150, the text says, shows a pressure gage attached, yet none is to be seen. In the index just before "Dead Center" and "Dead Plate" is listed "Dead Boiler Feed Pump," page 146, where Fig. 153 shows a Deane pump; not Dead. The index under economizers refers us to page 591 when there are less than 400 pages in the book. And the subject of economizers is disposed of under "Feed Pipe" in a space of twelve lines and one inferior cut. The subject "Air Lift," page 282, has less than a hundred words, and the closing statement is that "The height to which the water is lifted depends upon the air pressure which is furnished by the compressor." Again, on page 157, the only reason offered for counterboring is, "The cylinder is counterbored at each end to facilitate the introduction of the piston."

The problems to be found at the close of each chapter are excellent and furnish good exercise for the student and for examinations.

New Government Publications—The Bureau of Mines, Department of the Interior, has recently issued the following new publications.

BULLETIN 38. The origin of coal, by David White and Reinhardt Thiessen, with a chapter on the formation of coal, by C. A. Davis. 1914. 390 pp. 54 pls.

TECHNICAL PAPER 34. Experiments with furnaces for a hand-fired return tubular boiler, by S. C. Flagg. 1914. 32 pp., 4 Figs.

TECHNICAL PAPER 63. Factors governing the combustion of coal in boiler furnaces, a preliminary report, by J. K. Clement, J. C. W. Frazer and C. E. Augustine. 1914. 46 pp., 26 Figs.

TECHNICAL PAPER 77. Report of the Committee on Resuscitation from Mine Gases, by W. B. Cannon, G. W. Crile, Joseph Erlanger, Yandell Henderson, and S. T. Meltzer. 1914. 36 pp., 4 Figs.

TECHNICAL PAPER 79. Electric lights for use about oil and gas wells, by H. H. Clark. 1914. 8 pp.

MINERS' CIRCULAR 17. Accidents from falls of rock and ore, by Edwin Higgins. 1914. 15 pp., 8 Figs.

Note—Only a limited supply of these publications is available for free distribution, and applicants are asked to coöperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers cannot be granted without satisfactory reason. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

MECHANICAL LABORATORY METHODS. The Testing of Instruments and Machines in the Mechanical Engineering Laboratory and in Practice. By Julian C. Smallwood, M. E., Associate Professor of Experimental Engineering, Syracuse University. Published by D. Van Nostrand Co., New York. Limp leather binding; 332 pages; 5x7½ in.; 95 illustrations. Price, $2.50.

The subtitle is clearly descriptive of the subject matter, and while the main purpose has been to provide a handbook for the use of college students in mechanical laboratory practice, the work is one which should find a place among handbooks of engineering graduates and practical engineers who appreciate suggestions on the handling of apparatus and guidance in the essentials of engineering tests. The author gives as his reason for undertaking a subject already treated by a few admirable texts that in his own teaching there appeared need of a brief work on the broad principles of experimental apparatus and methods. The book does not contain lengthy or detailed descriptions of instruments of any class, but it is assumed that the reader is familiar with the general principles and purposes beforehand. In dealing with any class of instruments, the text explains only the broad principles of that class or a subdivision, so that only a brief explanation covers any specific instrument.

With the purpose of making more direct and simpler presentations, the illustrations are diagrammatic without detailed drawings or pictorial effect. While this method is undoubtedly sufficient, and for some reasons may be better for the explanation of abstract principles, the work could have been made no less valuable to students, and certainly would have been more acceptable to practical engineers, if the plan of illustrating had been carried out less rigorously, as by the addition of good pictorial illustrations of typical instruments and appliances.

Two main divisions of the work deal respectively with testing of instruments and machines. The first is subdivided, so as to deal separately with a group of instruments of a single type for a given purpose as instruments, and under each subdivision the principles of the instruments considered are first related and then are given the methods of testing them. Part 1 relates to the principles and calibration of instruments for determining weights and forces, pressure, angular velocity, brakes and dynamometers for measurement of power, steam engine indicators, planimeters, temperature and heat, oil and belt testers.

Part 2, on the analysis of combustion, is subdivided under heads of determination of constituents of fuels, and heat values of fuels and products of combustion.

Part 3, "The Testing of Power Plant Units," is subdivided under principles and methods of testing steam engines, steam turbines, conducting economy tests and testing steam pumps, air machinery and water motors.

The work being exclusively on the subject of testing, the principles of all except a few types of engines and topics such as thermodynamics have not been included. Only simple algebraical formulas are employed. The author's style is generally terse and clear, and the text is additionally clarified by being well paragraphed. The work is printed on good paper, in large, readable type. The subheads of the text are in bold-faced type, and for readier reference there is given a convenient alphabetical index in addition to a complete tables of contents, showing the divisions and subdivisions of subjects.

Government Aid in Selection of Coal—Requests for data relative to coal analyses are frequently received. For the information of engineers who desire the latest published material we advise writing the United States Geological Survey, which each summer issues a small pamphlet giving analyses made by the Bureau of Mines of the coal samples that the Survey has collected during the year. The heating value is given with almost all the analyses, so that it is easy to determine which of two coals is the better. The bulletin also gives a brief description of the samples, including a section of the coal at the point sampled, and an outline of the different classes of coals recognized by the Geological Survey. A copy of Bulletin 541-K may be obtained free of charge on application to the Director of the United States Geological Survey, Washington, D. C.

OBITUARY

John S. Smith, 83, who was an engineer officer in the navy during the Civil War, died on Sunday, Sept. 20, at his home, 161 Madison St., Brooklyn. He was engineer of the "Stonington," of the Fall River Line, at the time it came into collision with the "Narragansett." He leaves three sons and two daughters.

PERSONALS

Edward J. Kunze, who for the past four years has been assistant professor of mechanical engineering at the Michigan Agricultural College, has been appointed professor of mechanical engineering of the Oklahoma Agricultural and Mechanical College, in charge of the department.

NEW EQUIPMENT

ATLANTIC COAST STATES

Lightning recently damaged the Bangs power station of the Central Maine Power Co., Waterville, Maine, to the extent of $30,000.

Bids will be received by Walter B. Forbush, Comr. of Pub. Bldgs., Newton, Mass., until Sept. 30, for installing heating and ventilating apparatus in the Claflin School buildings on Walnut St., Newton. Alfred S. Kellogg, 53 State St., Boston, is Engr.

The Board of Selectmen, Reading, Mass., contemplates making improvements and extensions to the municipal electric-light plant at an estimated cost of $8000. Arthur G. Sias is Mgr. and Supt. of the plant.

Bids are being received by Greenwood & Noer, Consult. Engrs., Hartford, Conn., for the construction of a power house at Georgetown, Conn., for the Gilbert & Bennett Mfg. Co.

SOUTHERN STATES

The construction of an electric-light plant to cost $100,000 is contemplated by the Beckley Utilities Co., Beckley, W. Va. James Imboden, Charleston, is Consult. Engr.

Bonds for $40,000 have been voted by the citizens of Quitman, Ga., the proceeds of which will be used for the enlargement of the electric-light plant. New equipment will be purchased. J. M. Curtright is Supt.

POWER

Vol. 10 NEW YORK, OCTOBER 6, 1911 No. 14

Fire Often, Fire Light

By R. T. Strohm

IF your boss begins complaining
That his power bill is draining
Every cent he has remaining
In a fashion expedite,
Take the hint that he's conveying
And remember that he's paying
You for working, not for playing—
Fire often, fire light.

IF the chimney belches gases
That deposit sooty masses
On the pretty girl that passes
In her dainty dress of white,
Don't assume a manner humble
And attempt to smirk and mumble
Your excuses. Take a tumble—
Fire often, fire light.

DON'T get hot beneath the collar
If the boss puts up the holler
That you lose from every dollar
Half its purchase power, quite.
Common Sense, the great physician,
Will prescribe for your condition
Just this simple admonition—
Fire often, fire light.

QUIT your dozing and your dreaming;
While you fire, get to scheming
How to raise the rate of steaming
To an economic height.
For the boss will be your debtor
If you follow to the letter
This advice—there's nothing better—
Fire often, fire light.

Bakersfield, Calif., Steam Power Plant

SYNOPSIS—Construction of this plant was begun in 1910, and was in progress intermittently until the fall of 1913. The demand for electrical energy was so rapid that the installation of additional equipment kept the plant in an unfinished state during practically all of that time, thus rendering its operation somewhat difficult. Notwithstanding these drawbacks, however, the operating record of the plant is excellent. There are three turbo-generators, of 2500-, 6250-, 7800-kv.a. capacity. Steam is supplied by 12 water-tube boilers, a total of 6048 h.p. Water for condensing purposes is taken from an irrigation canal, 75 ft. west of the plant. The auxiliaries, including exciters, air and circulating pumps, boiler feed and general-service pumps, are on the ground floor. The electrical equipment is on the three floors of the lean-to on the west side of the turbine room.

⁂

The growth of the San Joaquin Light & Power Corporation has been rapid. In 1909, the total generating capacity was approximately 4500 kv.a., then grew to 40,000 kv.a. in 1913, at which time there was an additional 6000 kv.a. capacity on order or being installed.

In 1910 the property of the Power Transit & Light Co., of Bakersfield, Calif., was acquired. This gave an additional source of electrical supply in a hydro-electric plant on the Kern River, consisting of three 450-kv.a. horizontal units which had been installed some 15 years before, and which were wholly inadequate for the demands required. Although the acquisition of this plant made a valuable addition to the generating capacity of the system, it was realized that it was not capable of meeting the overloaded conditions locally, nor was it of material assistance for peak conditions over the entire southern part of the system. Therefore, it was decided that the remedy lay in building a plant which would ultimately become the principal reserve steam plant of the southern part of the system. With this in mind, Bakersfield, Calif., was selected. The site fixed upon was adjacent to an irrigation canal of the Kern Island Canal Co., this being the only reliable source of water supply

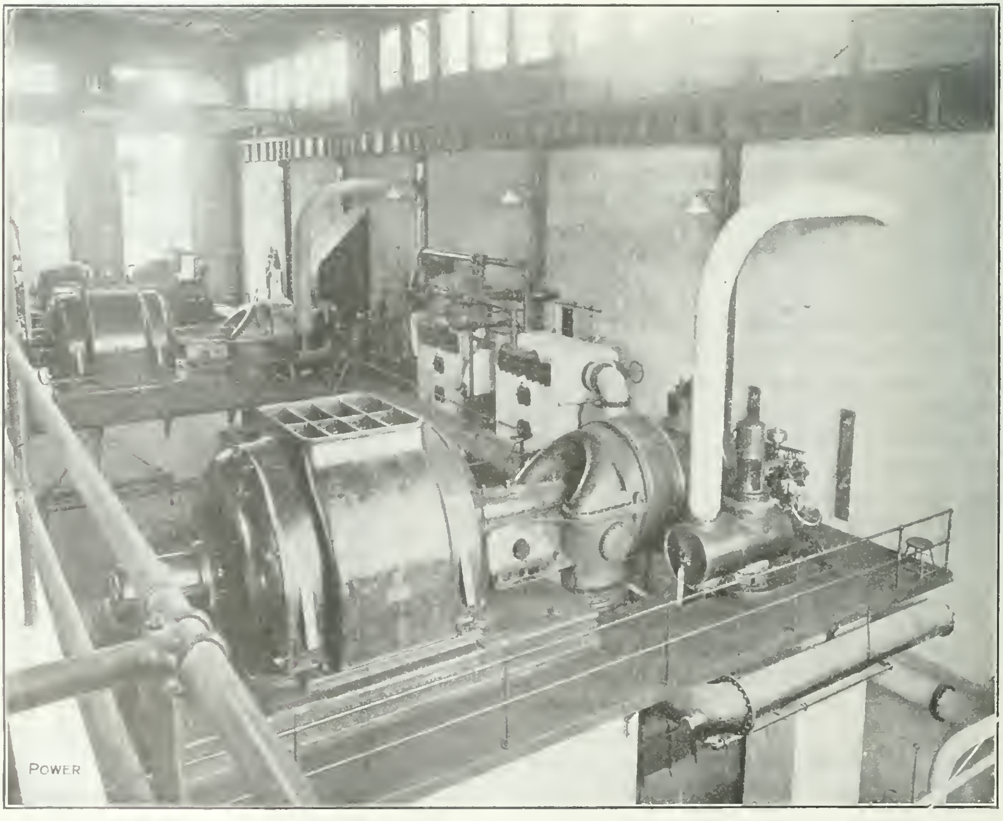

FIG. 1. GENERAL VIEW OF THE TURBINE ROOM FROM THE GALLERY

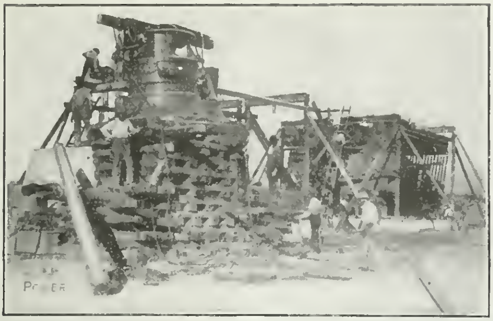

Fig. 2. Erecting the Temporary Generating Unit and Boilers

having sufficient water for condensing purposes. The power plant is built on a 15-acre plot east of this canal and about 2000 ft. north of the main San Joaquin Valley branch of the Southern Pacific Ry.

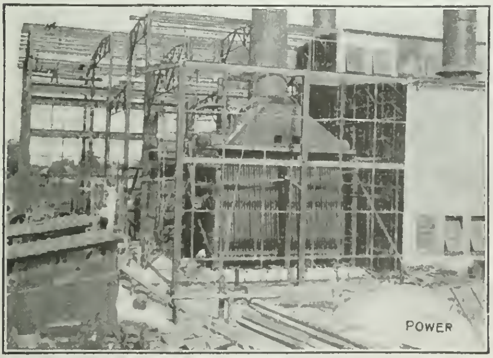

Fig. 3. Extending the Plant While Erecting Additional Units

As originally designed, the plant was to contain two 2500-kv.a. turbo-generators; the first to be placed at once and the other later. Before the first unit could be procured, however, it became necessary, because of the urgent demand for energy, to secure a temporary generator; a 750-kv.a. vertical unit was the largest available; four 304-hp. boilers were also secured. With this equipment as a nucleus, a temporary plant was constructed and put in operation 49 days after this equipment reached the grounds and some time before even the steel for the main building had been delivered. Fig. 2 shows the apparatus being installed, no evidence of a building being seen. When the temporary plant was first started, the boilers were without shelter and the turbine, the switchboard and the exciter were inclosed in a temporary shed for protection while the permanent building was being erected.

The power-plant building is of fireproof construction, with self-supporting steel frame and concrete walls, partitions and roofs, reinforced with Hy-rib steel. All the floors are of concrete; those in the galleries being reinforced with wire mesh. The turbine room is approximately 40 ft. wide by 145 ft. long. Adjacent to this on the west is the electrical lean-to, a structure 20 ft. wide and 145 ft. long; the boiler room is 81 ft. 8 in. wide by 125 ft. long. The lean-to is arranged in three levels. The ground floor houses the transformers, generator and low-tension transformer switches, motor-generator sets, 2300-volt altenating-current busbars, oil switches for local service and switchboard for control of the auxiliaries. The first gallery or operating floor level carries the main switchboard, 10,000-volt alternating-current busbars and oil switches. From this gallery platforms attached to the operating platforms around the generating units connect on the east side with the platform around the heaters,

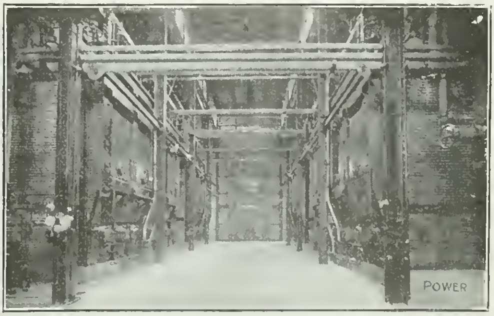

Fig. 5. Boiler Room Containing 12 Water-Tube Boilers

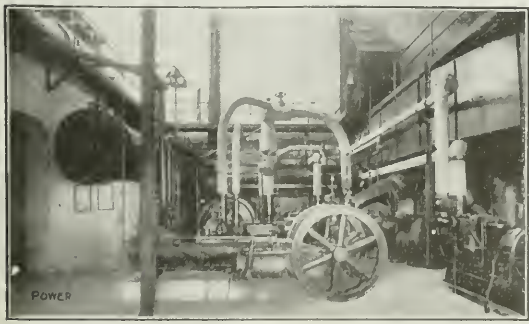

Fig. 4. Condenser Equipment for the 2500-Kv.-A. Unit

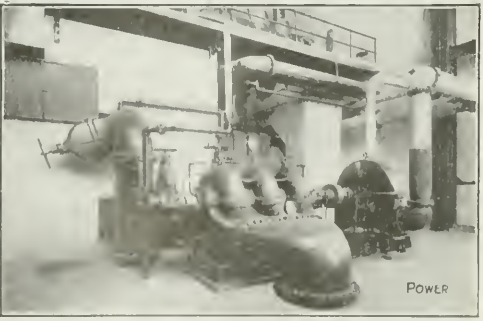

Fig. 6. Tri-Rotor, Turbine Centrifugal Pump

that all units on this level are accessible from any part of the power house. The third floor contains the 60,000-volt alternating-current busbars and oil switches. The outgoing and incoming feeders go through the west side of the lean-to.

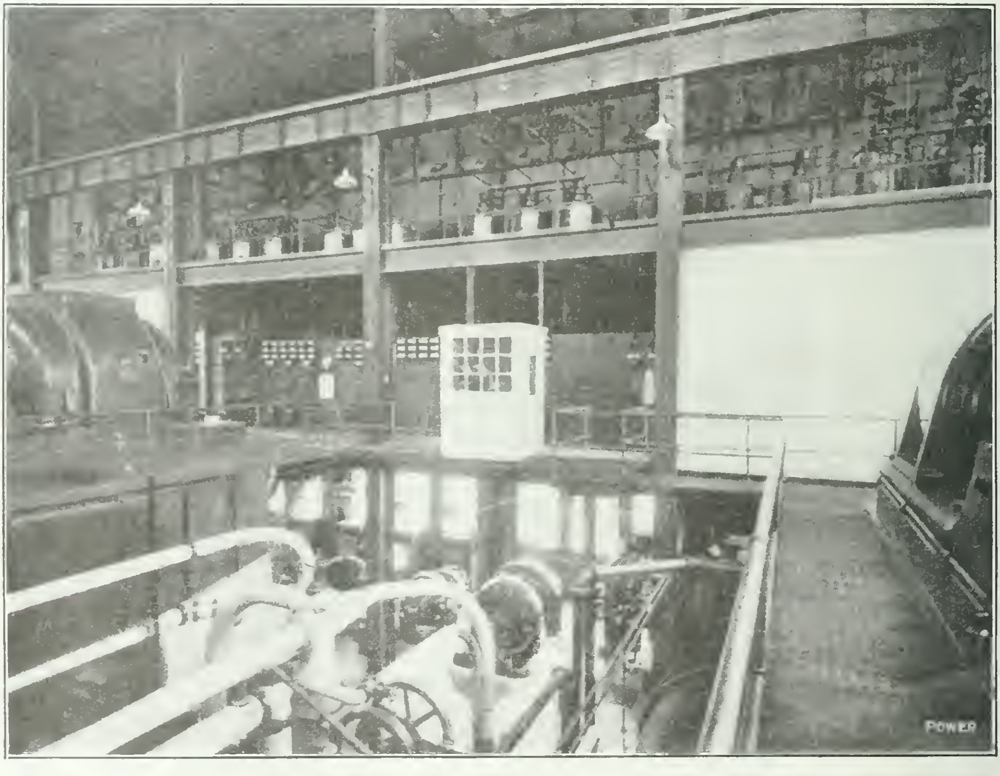

Fig. 7. View of the Galleries and Exciter Units

Turbo-Generators

Owing to the rapid growth of the company's business, the original plan of installing two 2500-kv.a. units was abandoned, and in place of the second 2500-kv.a. machine a 6250-kv.a. unit was selected. The third unit is of 7800-kv.a. capacity. The first temporary unit was put in operation early in 1911; the second in November of the same year, and the third unit late in 1913.

Although the capacity of the second unit is more than twice that of the one contemplated when the plant was designed, it was not necessary to make any changes in the turbine room to accommodate this larger unit; in fact, the only deviation from the original plan was in building a 20x20-ft. addition to the electrical lean-to to house the transformers, and when the third unit was installed it was possible to make the turbine room symmetrical. Although the capacity of the third unit is 1550 kv.a. greater than that of the second, it occupies practically the same amount of floor space, due to the modification in design of the turbo-generators during even the short interval between the dates on which these two machines were purchased.

To house the third unit, it was necessary to extend the turbine room and electrical lean-to south about 60 ft., and the boiler-room about 40 ft. to the full width and height of the original structure, Fig. 3. The plant now has a capacity of 16,550 kv.a. in three units. The general view of the operating floor of the turbine room as seen from the south end of the 10,000-volt gallery is shown in Fig. 1. Fig. 7 is a view of the electrical lean-to looking west from a position between Nos. 1 and 2 turbines. In the foreground to the left, adjacent to the foundation of No. 2 generator, is the 75-kw. turbo-driven, 125-volt exciter unit. Between the two motor-generator sets is a 100-kw. exciter driven by an induction motor. These units also supply energy for operating a 35-ton electric traveling crane, a portable motor-driven air compressor and for emergency lighting.

Condensers

A separate condensing outfit is furnished for each main turbine. That for the 2500-kv.a. unit contains 6000 sq.ft. of cooling surface in $\frac{3}{4}$-in. brass tubes, or 2.4 sq.ft. of surface per kv.a. Each of the other two condensers has 15,000 sq.ft. of cooling surface, the tubes in No. 2 condenser being $\frac{3}{4}$ in. and in No. 3 condenser 1 in. In the No. 2

condenser the number of square feet of cooling surface is the same as in No. 1. No. 3 unit contains 1.9 sq.ft. of surface per kv.a. capacity.

There are three condenser circulating pumps, two of the single-stage centrifugal type, driven by horizontal compound, noncondensing engines, having 9 and 17 by 12-in. cylinders. The last circulating pump installed is of the multi-rotor centrifugal type, driven by a directly connected noncondensing steam turbine.

Each of the engine-driven units has a capacity of 10,000 gal. per minute; and the turbo-driven unit 15,000 gal. The capacities of these pumps are such that either of the engine-driven units will furnish sufficient water for the two smaller turbines, and one of these, in conjunction with the turbine-driven pump, will furnish water for all three turbines. The piping from the pumps to the condensers is designed for operating the station in this manner. Fig. 4 shows the arrangement of the condenser for the 2500-kv.a. turbine, the rotative dry-vacuum pump being in the foreground and the engine-driven circulating pumps at the rear. The 75 kw. turbo-exciter set is to the right of the air pump. The steel-plate duct supplies air for the 6250 kv.a. generator.

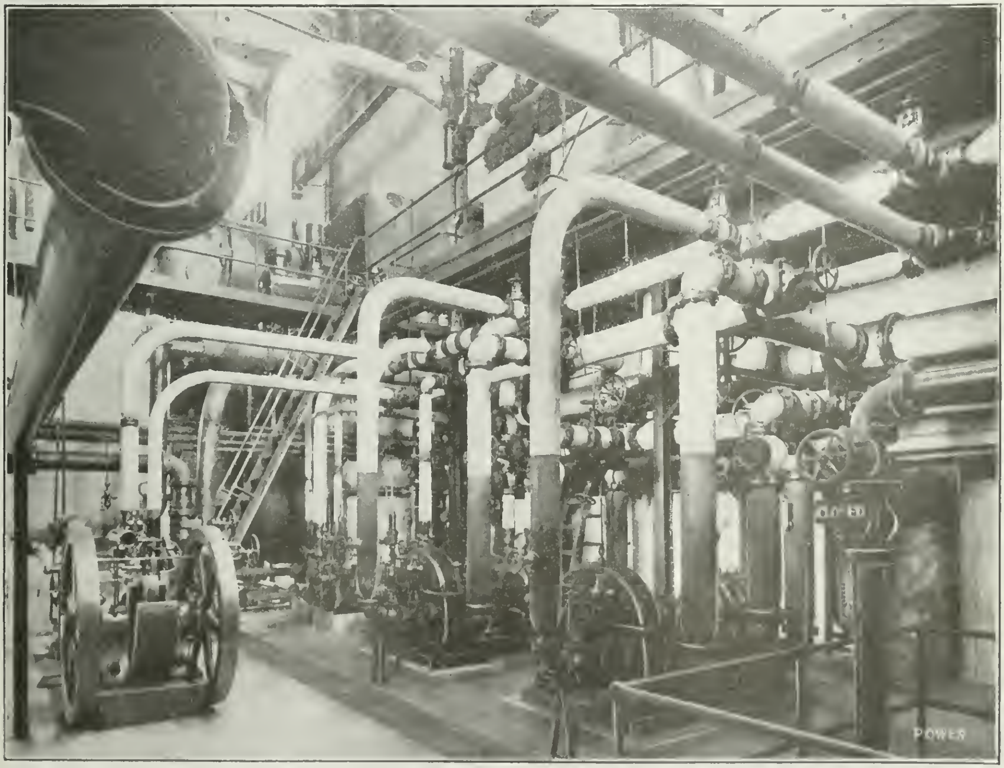

FIG. 8. TURBINE-DRIVEN BOILER-FEED PUMPS AND SERVICE PUMPS

The tri-rotor turbine-driven centrifugal pump for the 7800 kv.a. turbine and a portion of the condenser for this unit is shown in Fig. 6. The duct in the upper left foreground supplies air for the No. 3 unit. A 6 and 7¼ by 6 in. direct-acting piston pump removes the condensate from No. 1 condenser. On unit No. 2 there are two 3-in. centrifugal pumps, one turbine and one motor driven. One 4-in. turbine-driven circulating pump is used in conjunction with No. 3 condenser. Air is removed from No. 1 condenser by a 10 and 18 by 18-in. tandem center-crank rotative dry-vacuum pump. Each of the other two condensers is equipped with a 12 and 30 by 18-in. air pump of the same type.

Condensing water is taken from the irrigation canal, which is about 75 ft. west of the plant, and after passing through the condensers is returned to the ditch at a point south of the plant and sufficiently far from the intake to prevent heating the supply water. The intake from the canal has duplicate screen chambers, the area of which is much in excess of the two 26-in. cast-iron pipe lines which connect with the suction of the circulating pumps.

BOILERS

The steam generators consist of 12 water-tube boilers designed for 200 lb. working pressure, Fig. 5; four are rated at 304 hp. each, and the remaining eight are of 601 hp. capacity each. The latter are equipped with "I"-type superheaters, which superheat the steam from 100 to 125 deg. All of the boiler furnaces burn crude oil.

Oil is delivered to the plant on a spur of the Southern Pacific Ry., and is stored in a 2500-bbl. capacity steel tank placed conveniently for receiving oil by gravity from the cars. The tank is buried to within 1 ft. of its top and is protected by a roof. Provision is made for heating the oil in cold weather and also for fire suppression. The oil is heated and delivered to the burners by two fuel-oil sets, each consisting of two 5¼ and 4¾ by 5 in. fuel-oil pumps; one vertical exhaust-steam oil heater and one vertical multi-coil, high-pressure oil heater. These heaters maintain the temperature of the oil fed to the burners at approximately 180 deg. under the most severe operating conditions.

BOILER-FEED SUPPLY

Water for the boilers is obtained from two 90-ft. deep wells by vertical centrifugal pumps directly connected to induction motors, and is pumped to a 2500-gal. steel tank supported on the roof members of the boiler house. From this tank the water flows by gravity to the piping systems. Makeup water for the two 4000-hp. open feed-water heaters is obtained from this tank. These heaters raise the water to a temperature of approximately 200 deg., which then flows by gravity to two turbine-driven multi-stage boiler-feed pumps, each of 600 gal. per min. capacity, against a discharge head of 250 lb. per sq.in. The turbines on these units are each of 137 hp., and

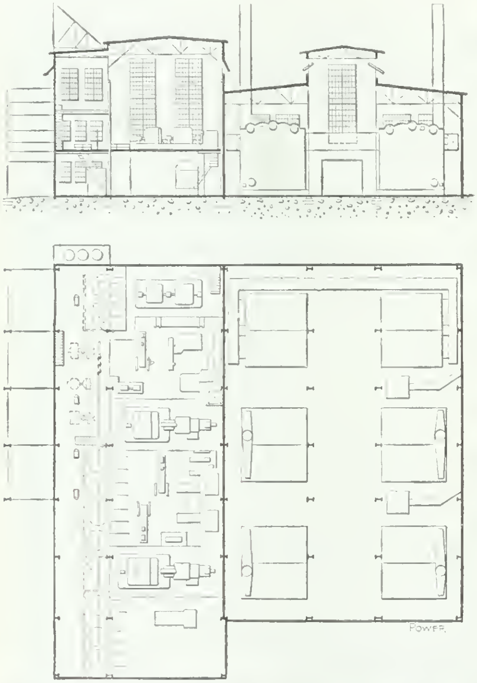

FIG. 9. PLAN AND ELEVATION OF THE POWER PLANT

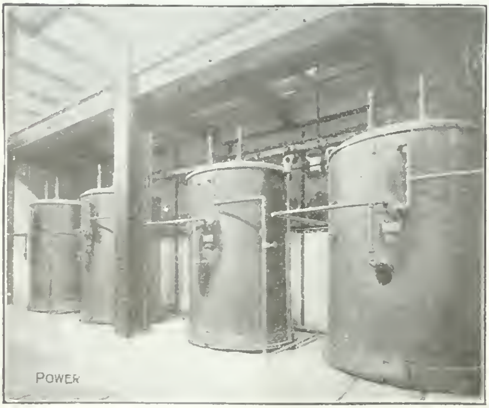

FIG. 10. WATER PIPING AND ELECTRICAL CONNECTIONS OF THE 2100-KV.-A TRANSFORMERS

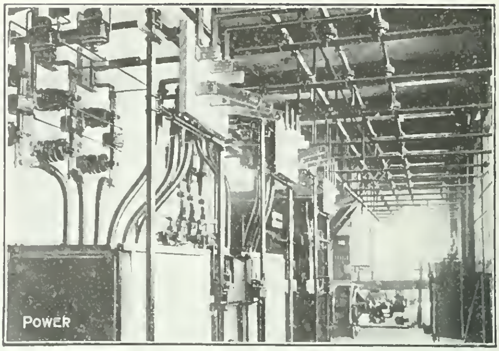

FIG. 11. BUSBARS AND OIL SWITCHES

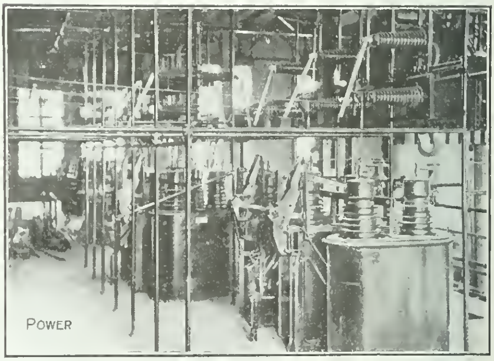

FIG. 12. 10,000-VOLT BUSSES AND OIL SWITCHES

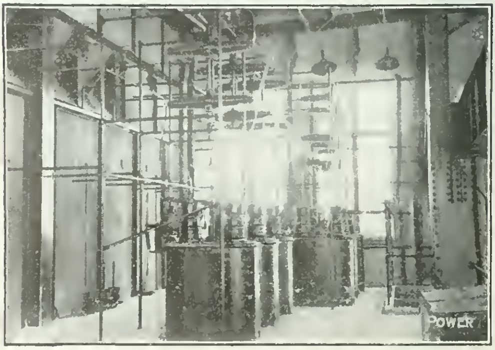

FIG. 13. THE 60,000-VOLT BUSSES AND OIL SWITCHES

exhaust into the open heaters. In addition, there are also two 9 and 5 by 10-in. plunger-type pressure pumps for filling and cleaning boilers and for miscellaneous purposes.

In Fig. 8 can be seen the turbine-driven boiler feed and the general service pumps. Fig. 3 shows the two feed-water heaters on the turbine-operating floor level.

Piping

The main steam piping is designed for 200 lb. working pressure and 100 deg. superheat. The 6-in. pipes from each boiler connect to a main 10-in. header from which a 10-in. branch line goes to each of the two larger turbines and an 8-in. line to the small one. All joints are of the van-stone type with steel flanges, and all the fittings and valves are of steel. Each boiler is protected by an automatic nonreturn stop and check valve, and the lead to each turbine has an emergency remote-control valve permitting any one of the units being shut off from a distance in case of an accident to the turbine or to the steam

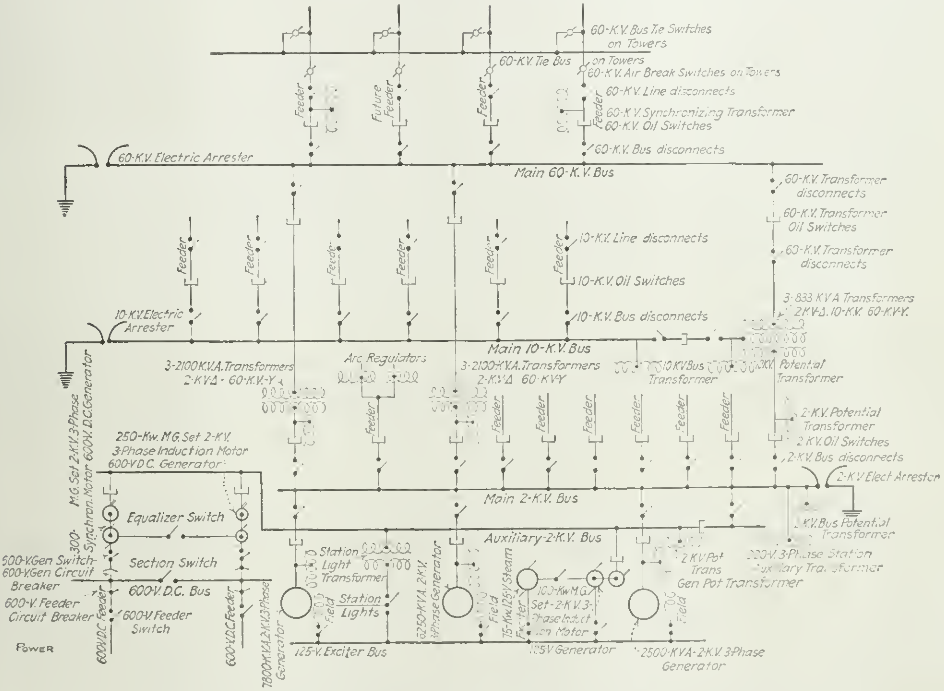
60-K.V. Bus Tie Switches on Towers
60-K.V. Tie Bus
on Towers
60-K.V. Air Break Switches on Towers
60-K.V. Line disconnects
60-K.V. Synchronizing Transformer
60-K.V. Oil Switches
60-K.V. Bus disconnects
Feeder
Future Feeder
Feeder
Feeder
60-K.V. Electric Arrester
Main 60-K.V. Bus
60-K.V. Transformer disconnects
60-K.V. Transformer Oil Switches
60-K.V. Transformer disconnects
Feeder
Feeder
Feeder
Feeder
Feeder
Feeder
10-K.V. Line disconnects
10-K.V. Oil Switches
10-K.V. Bus disconnects
3-833 K.V.A. Transformers 2KV-Δ. 10-K.V. 60-K.V.-Y.
10-K.V. Electric Arrester
Main 10-K.V. Bus
3-2100 K.V.A. Transformers 2-K.V.Δ · 60-K.V.-Y
Arc Regulators
3-2100 K.V.A. Transformers 2-K.V.Δ 60-K.V.-Y
10 KV Bus Transformer
Potential Transformer
Feeder
Feeder
Feeder
Feeder
Feeder
Feeder
Feeder
2-K.V. Potential Transformer
2 K.V. Oil Switches
2-K.V. Bus disconnects
2-K.V. Elect Arrester
M.G. Set 2-K.V. 3-Phase 300-Synchron. Motor 600-V. D.C. Generator
250-Kw. M.G. Set 2-K.V. 3-Phase Induction Motor 600-V D.C. Generator
Main 2-K.V. Bus
K.V. Bus Potential Transformer
Equalizer Switch
Auxiliary-2-K.V. Bus
2 K.V. Pot Trans
Gen Pot Transformer
220-V. 3-Phase Station Auxiliary Transformer
500-V. Gen Switch
600-V. Gen Circuit Breaker
Section Switch
Station Light Transformer
600-V. D.C. Bus
600-V. Feeder Circuit Breaker
600-V. Feeder Switch
Station Lights
Field
6250-K.V.A. 2-K.V. 3-Phase Generator
Field
75-Kw. 125-V. Steam Exciter
100-Kw. M.G. Set-2-K.V. 3-Phase Induction Motor
Field
600-V. D.C. Feeder
600-V. D.C. Feeder
7800-K.V.A. 2-K.V. 3-Phase Generator
125-V. Exciter Bus
125-V. Generator
2500-K.V.A.-2-K.V. 3-Phase Generator
Power

Fig. 14. Wiring Diagram of the Plant, Showing Connections

PRINCIPAL EQUIPMENT OF THE BAKERSFIELD STEAM-TURBINE POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-gen......	Curtis horizontal..	2500 kv.a.....	Main generating unit....	190 lb. steam, 100 deg. superheat, 28″ vac., 1800 r.p.m.	General Electric Co.
1	Turbo-gen.....	Allis-Parsons......	6250 kv.a.....	Main generating unit.....	190 lb. steam, 100 deg. superheat, 28″ vac., 1800 r.p.m.	Allis-Chalmers Co.
1	Turbo-gen......	Allis-Parsons......	7800 kv.a.....	Main generating unit ...	190 lb. steam, 100 deg. superheat, 28″ vac., 1800 r.p.m.	Allis-Chalmers Co.
1	Turbo-gen......	Curtis, single-stage.	75 kw.........	Exciter and emergency station lighting......	190 lb. steam, 125 volt	General Electric Co.
1	Motor-gen.....	Induction, direct current.........	100 kw......	Exciter and emergency station lighting......	Three-phase, 60 cycle.	General Electric Co.
2	Engines........	Reciprocating.....	9x17x12.	Driving circulating pumps	Non-condensing....	Harrisburg Foundry & Mch. Co.
2	Pumps........	Centrifugal, single-stage...........	10,000 gal. per min.........	Circulating pump........	....	Alberger Pump & Condenser Co.
1	Turbine.......	Single-stage.......	....	Driving circulating pump	Non-condensing	Alberger Pump & Condenser Co.
1	Pump......	Centrifugal, multiple motor......	15,000 gal. per min......	Circulating pump.......	....	Alberger Pump & Condenser Co.
4	Boilers........	B. & W............	304 hp........	Steam generators........	200 lb. pressure, two burn oil, two burn natural gas............	Babcock & Wilcox
8	Boilers........	Stirling U superheaters.........	601 hp........	Steam generators........	200 lb. pressure, burning crude oil	Babcock & Wilcox
2	Heaters........	Open.............	4000 hp.......	Heating boiler feed water	Exhaust steam from auxiliaries......	Harrison Safety Boiler Works
2	Turbines.......	Single-stage.......	137 hp... .	Driving boiler feed pumps	200 lb. steam pressure.	Alberger Pump & Condenser Co.
2	Pumps........	Multi-stage cen....	600 gal. cap. .	Boiler feed pumps.....	Turbine driven	Alberger Pump & Condenser Co.
2	Pumps........	Plunger...........	9x5x10-in ..	Miscellaneous.	Steam driven...	Henry R. Worthington
2	Pumps........	Plunger...........	5¼x1¾x5-in . .	Pumping fuel oil.........	Steam driven...	Platt Iron Works
1	Pumps........	Rotating..........	10x18x18-in .	No. 1 condenser.	Steam driven..	Alberger Pump & Condenser Co.
2	Pumps........	Rotating..........	12x30x18	Nos. 2 and 3 condensers..	Steam driven...	Alberger Pump & Condenser Co.
1	Condenser.....	Surface..........	6000 sq.ft. surface... .	No. 1 turbine.	28-29-in. vacuum...	Alberger Pump & Condenser Co.
2	Condensers.....	Surface...........	15,000 sq.ft. surface .	Nos. 2 and 3 turbines....	28-29-in. vacuum	Alberger Pump & Condenser Co.
8	Valves.........	Non-return........	6-in.... .	Steam pipes from boilers..	Automatic.....	Schutte & Koerting Co.
3	Valves.........	Emergency........	1 8-in. 2 10-in.	Steam lines to turbines..	Remote control.	Schutte & Koerting Co.
	Valves.........	Several...........	Various	Miscellaneous	....	Crane Co.
4	Transformers...	Water cooled......	833 kv.a......	Transforming for line....	2300-11,000, 40,000-60,000 Y volts	General Electric Co.
4	Transformers...	Water cooled......	2100 kv.a.....	Transforming for line.....	2300-10,000, 60,000 Y volt	Allis-Chalmers Co.
1	Motor-generator	Direct current.....	300 kw	Railway work...	....	General Electric Co.
1	Motor-generator	Direct current.....	225 kw..	Railway work.........	....	General Electric Co.

line supplying it. Expansion is taken care of by means of 90-deg. bends in the leads from each boiler and by two U-bends in the main header. All steam and exhaust lines, feed-water heaters, traps, etc., are insulated with 85 per cent. magnesia covering, the thickness varying with the service required.

ELECTRICAL EQUIPMENT

The electrical-control equipment and busses are directly to the west of the turbine room. There are four 833-kv.a. water-cooled transformers, and in Fig. 10 are shown the water piping and electrical connections for four 2100-kv.a. transformers. There are also on this level a 225-kw. and a 300-kw. motor-generator set, as well as the 2300-volt busbars and oil switches and switchboard for the control of the auxiliaries, Fig. 11.

The main switchboard, on the turbine-operating floor level, is shown in Fig. 7. Here are also the 10,000-volt busses and oil switches, Fig. 12. Both the 10,000- and 60,000-volt busses are of copper tubing; the 2300-volt busses are of copper bar. There are electrolytic lightning arresters for each of the three operating voltages connected to extensions of the several busses. The 60,000-volt bus and oil switches are on the third floor, Fig. 13.

TRANSMISSION LINES

The Bakersfield station was designed to eventually serve as the main steam reserve to the enlarged transmission system, and operate in parallel with it at 60,000 volts as well as supplement the output of the Kern Cañon plant; also to operate in parallel with it and the original transmission line at 11,000 volts. Furthermore, under certain conditions it was to operate as a rotary condenser station to correct the power factor of the transmission system as well as to serve as a substation supplying local service at 2300 volts, series alternating municipal lighting, and direct current at 600 volts for traction and motor service, all of which made the electrical layout of the plant unusually complicated.

To avoid duplication of equipment and at the same time to provide for the several voltages with which it was necessary to parallel and to supply the design, the first complement of transformers was a departure from standard practice. Each transformer, of 833-kv.a. capacity, has the usual primary coils for 60,000 volts and two secondary windings, one for 2300 and one for 11,000 volts, designed to deliver the full rated capacity of the transformers at their respective voltages. The seven 2100-kv.a. water-cooled transformers are wound for 23,000, 40,000 and 60,000 volts.

Electric current is furnished to Bakersfield from hydroelectric plants in the central part of the San Joaquin valley, about 100 miles north of Bakersfield, and from the Kern Cañon plant, about 20 miles east of Bakersfield.

Around the time that the first unit was started, the west side line of this transmission system had been completed. It has since been supplemented by a similarly constructed line on the east side and the steam plant at Bakersfield now stands at the south end of this loop. A wiring diagram of the plant, showing the method and plan of connection, is shown in Fig. 14.

New Water-Tube Boiler

The cross-drum, water-tube boiler, shown in Figs. 1, 2 and 3, embodies novel features worthy of noting. The furnace, which may be any height, is roofed over by water tubes, incased in refractory tile, thus forming practically a smokeless furnace for long-flame coal. The main bank of tubes is covered from end to end on the top row, and vertical side baffles are provided and perforated, the products of combustion finding outlet through the perforations.

A supplementary combustion chamber above the bottom row of tubes is created by omitting a number of tubes in the vertical rows. The products of combustion in entering this chamber are compelled to mix and blend, thus aiding in securing complete combustion prior to the gases coming in contact with the relatively colder boiler heating surface. The gases on entering this chamber are completely surrounded (top, sides and ends) by the heat-absorbing surfaces of the boiler. The gases then flow laterally toward the vertical baffles on the sides, and from thence flow upward into the upper chamber from which they pass to the chimney. The aim of the designer has been to eliminate brickwork outside the furnace proper, thus reducing the first cost, cost of upkeep, as well as the usual heat losses chargeable to radiation and infiltration of air.

Above the lower row of tubes the brickwork does not extend, as steel casing is used on sides and top. Inasmuch as the temperatures of the gases are quite low at such points, the cost of insulation for the steel casing is low and heat losses may be easily avoided. It will be noted that as the flow of the gases in the main bank of tubes is laterally, the gases are distributed more equally to the tubes, thus avoiding localizing the high temperature gases on the ends of the tubes.

By using 3 or 3½-in. tubes the gas passages between the tubes may be reduced to 2 in., which saves in floor space and increases the efficiency, and still it is possible to have low temperatures at the side baffles. There can be no infiltration of cold air (outside the furnace) to the high-temperature zone. In the upper chamber, 4-in. tubes connect the front header to the steam and water drum and at the rear similar tubes connect the drum to the top of the rear header.

Another horizontal row of tubes, which is out of the path of the gases, connects the front header to the rear one, and inasmuch as this row of tubes is "neutral" as respects absorbing heat, a return flow of water from the front to rear header will take place in these tubes, thus relieving the upper row, and the drum from duty to a large extent.

The headers or water-legs may be of the usual staybolted design, or of the separate design to embrace one or two vertical rows of tubes. As the temperatures in the upper chamber are very low the cross drum is not exposed to high heat and there its life is prolonged.

The soot is easily reached either through the side doors or by passages provided in the headers. The main bank of tubes is readily accessible for repairs or inspection through the supplementary combustion chamber, and from the sides and top by removal of the tile or baffle. The side baffles are suspended from the top tube in the outside row, and are readily removed for inspection. Superheaters may be easily installed by providing an opening in the rear header through which the piping can be readily inserted.

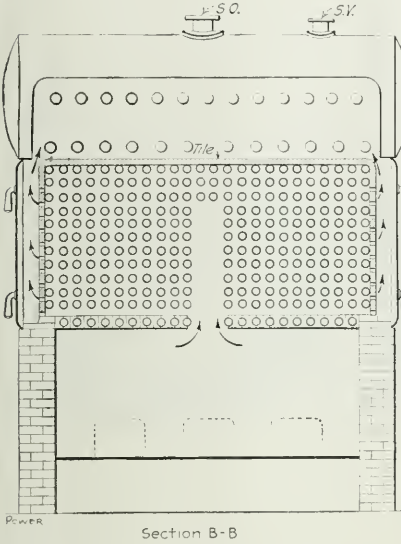

Fig. 1. Transverse section.

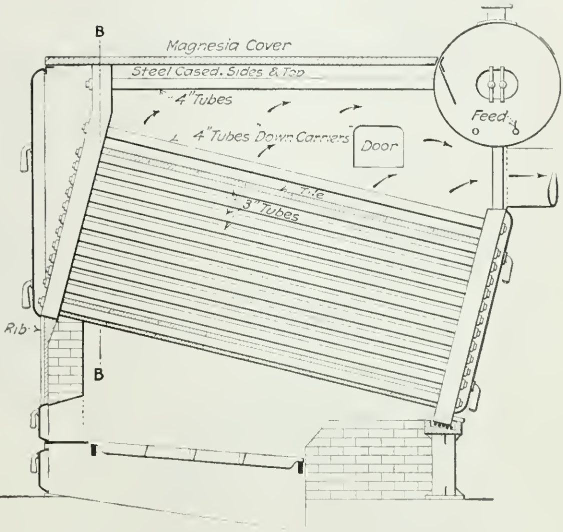

Fig. 2. Longitudinal section.

Double-Pass Type of the New Water-Tube Boiler

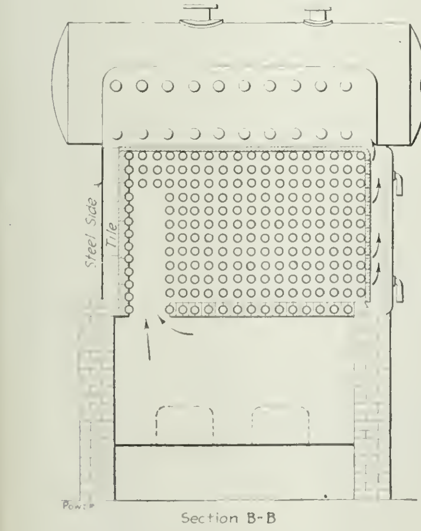

Fig. 3. Transverse Section of the Single-Pass Boiler

This design, while appropriate for any service, is specially adapted for city use, owing to the small floor space required, and, of course, its head room is no greater than with other types.

Fig. 3 shows a modification of the design for small units in which the tile on one side is protected by vertical water tubes. The "double-pass" design is for larger units, such as are now required for larger plants. The designer and patentee of the boiler is T. T. Parker, of New York City.

⁂

Keystone Stoker

Something new in stokers, Fig. 1, is being put out by the Keystone Stoker Co., of 111 Milk St., Boston, Mass. As may be seen from the illustrations, it is of the chain-grate type, but differs radically from others, in that the grate is made up of disks mounted on bars like rings on a cane. The whole chain is made up of these disks which move along toward the bridge-wall, rotating on their axes as they carry the fuel along. This feature is really the most important one in the design of the stoker. By reason of the revolving disks, a clinker that may form does not have an opportunity to stick to the disks and tends to become broken so that there is no serious plugging of the air spaces. Further, it will be seen that there is not one surface only on the fire side of the grate all the time, as with other chain grate stokers. As the disks revolve they get away from the fire or fuel-bed side and come in contact with the air-pressure side for their entire surface many times during their travel from the front to the bridge wall.

As the fuel bed is in more or less of a free state, it is not necessary to use very high draft pressure. The air velocity through the fuel bed should be quite uniform on this account, and therefore tends to burn the fuel evenly, preventing the formation of holes through which air may rush and not become mingled with the gases,

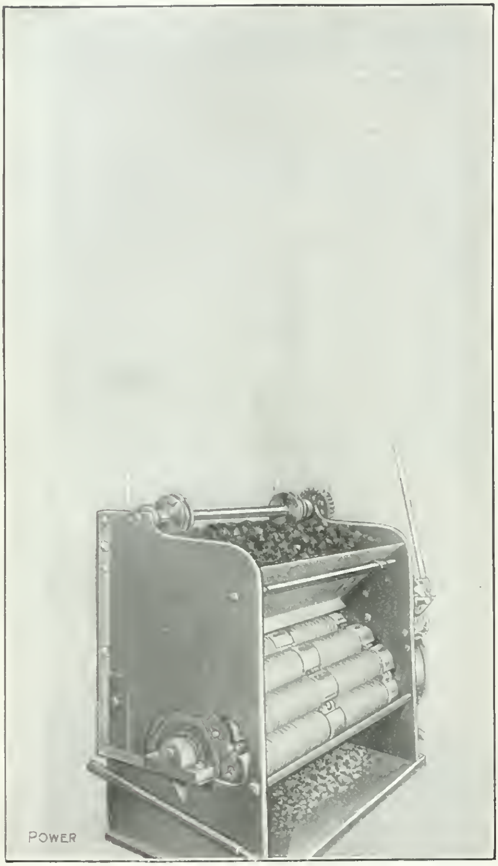

Fig. 1. The Keystone Stoker

thereby considerably increasing the free oxygen in the flue gases and also reducing the CO_2.

The number of revolutions that the bar carrying the disk will make in its travel through the fire is adjustable.

Another advantage of the stoker is the ease with which a new bar of disks may be inserted during the regular operation of the stoker. This is shown in Fig. 2, in which the operator has the stoker momentarily shut down, while with a pinch bar, he takes out a section of disks to be replaced by another section kept on hand for such purposes.

As will be seen from Fig. 3, a water box is used in the bridge wall to protect the masonry and prevent it from getting so hot as to melt away. These water boxes are not connected in any way with the boiler and cannot become a source of danger, as they may be simply piped to receive a small stream of water which can usually be utilized for steam or drained to the hotwell.

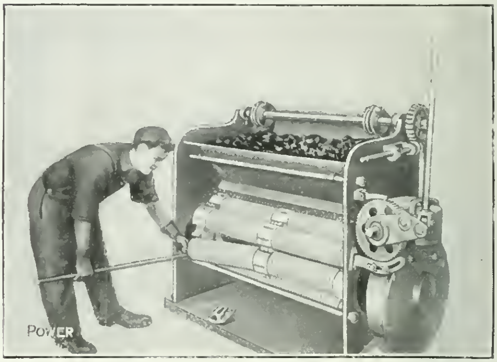

Fig. 2. Removing a Section of Disks While Stoker Is Momentarily Stopped

For taking care of the ashes, a sheet-iron apron is provided which extends across the width of the chain and as far back as any siftings would be likely to fall through. The action of the returning roller grates on this apron carries these siftings forward and deposits them on a front plate convenient for reclaiming; the ashes falling into the pit beyond this apron are seen to be kept separate.

As to the power required to operate this stoker, it is said that with a 20-in. crank attached to the gear shaft, one may easily revolve the stoker when carrying a fire. The chain glides on rollers and the driving sprocket is encased in oil. The stoker may easily be lowered or raised at the bridge wall to suit combustion while in

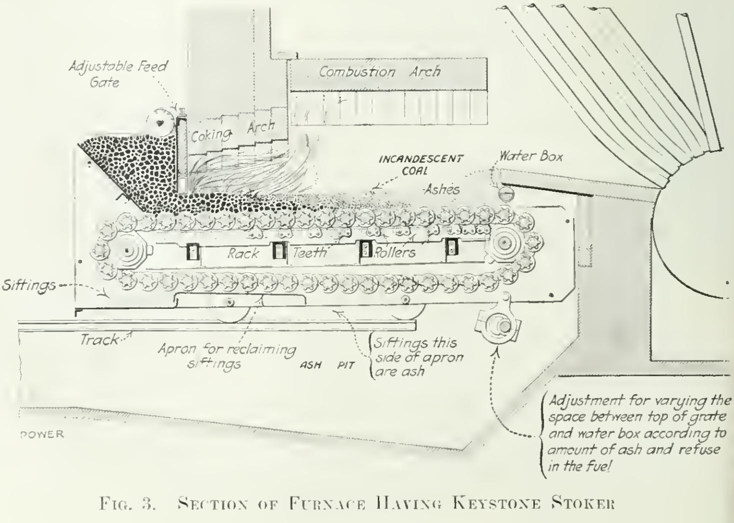
Adjustable Feed Gate
Combustion Arch
Coking Arch
INCANDESCENT COAL
Water Box
Ashes
Rack
Teeth
Rollers
Siftings
Track
Apron for reclaiming siftings
ASH PIT
Siftings this side of apron are ash
Adjustment for varying the space between top of grate and water box according to amount of ash and refuse in the fuel
POWER

Fig. 3. Section of Furnace Having Keystone Stoker

operation by an eccentric and a worm shaft reached from the side of the furnace. The amount of fuel sent to the furnace may be regulated by a slide gate, and the speed of the grate may also be regulated from the outside.

As will be seen in Fig. 3, the setting shown has a rather long ignition arch and a combustion arch to assist in burning the volatile. The stoker is of very heavy and rugged construction.

⁂ ⁂

Motors, Their Principles and Uses--III

By Gordon Fox

SYNOPSIS—Classification of polyphase alternating motors, together with the operating characteristics and methods of starting each type.

⁂

Alternating-current motors can be operated upon single-, two- or three-phase circuits. The earlier central stations generated for single-phase transmission and the few small motors then in service were of the single-phase type. When the use of electricity for power purposes was actively promoted it was found that the polyphase motor was better suited to most classes of work, particularly for the larger installations, consequently the polyphase system and polyphase motors have been highly developed and are now much more widely used.

Polyphase motors, in which class may be included all two- or three-phase machines, are of two distinct types, the induction and the synchronous motors. Of these the former is the more common.

The Induction Motor

The induction motor consists primarily of two parts, one stationary, the other rotating, each of which carries windings. The inside of the stator is slotted and its windings are made up of coils similar to those used in the armature of a direct-current motor. The rotor is also slotted and carries windings. Both the rotor and stator cores are built up of thin iron or steel punchings called laminations which are tightly stacked together; the general arrangement of winding is shown in Fig. 1. The coils of the stator are connected to form distinct groups of poles. In a two-phase motor there are two separate circuits and in a three-phase motor, three circuits. When alternating currents are applied to the stator windings a rotating field is set up.* Following the law of closed circuits in varying fields there are generated in these circuits counter voltages which oppose the impressed line voltages, due to which action only comparatively small currents flow through the low resistance of the stator circuits although large voltages are impressed.

While the current in one phase or circuit passes through a complete cycle the magnetism rotates through 360 magnetic degrees or the space of a pair of poles. This relation holds true no matter how many polar groups there may be on the stator. Consider a 60-cycle current impressed upon the windings of a six-pole motor which has windings arranged with six poles for each phase. For each cycle the field will shift over two polar spaces or one-third of the circumference. Hence the total speed of rotation will be 60 divided by three or 20 revolutions per second or 1200 per minute. In general, the speed per minute equals

$$\frac{cycles \times 60 \times 2}{number\ of\ poles}$$

Now consider the rotor to be placed in this rotating field. Its conductors are cut by the shifting lines of force and an electromotive force is induced in them. As they are arranged in closed circuits a current flows through them. A current flowing through a conductor in a magnetic field sets up a torque as was stated in Part I† and this sets the rotor in motion. If there is no load upon the shaft the rotor will pick up speed until it rotates nearly as fast as the rotating field. It can never quite attain a speed in synchronism with the rotating field, for if it did no lines of force would be cut and there would be no torque to overcome friction, etc. As load is placed upon the shaft the rotor lags or "slips" behind synchronous speed so that more magnetic lines are cut, more current is generated and enough torque results to meet the demands of the load.

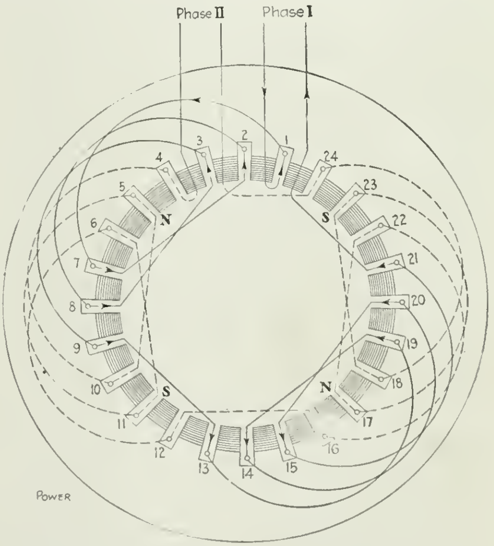

Fig. 1. Arrangement of Stator Wining in Two-Phase Motor

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*For a description of this rotating field action see "Power," Oct. 14, 1913, page 536.

†See Sept. 22, 1914, issue.

It is evident that the current in the rotor varies with the load, although it is entirely separate from the primary circuits. It will now be shown how this demand for energy is transmitted to the supply circuit. The currents in the rotor have a magnetizing effect which opposes the primary magnetism and it will be recalled that the current in the primary is controlled by the counter electromotive force induced by the primary magnetism. As the rotor magnetizing effect opposes the primary magnetism the counter electromotive force is reduced and a greater primary current is received from the supply circuit.

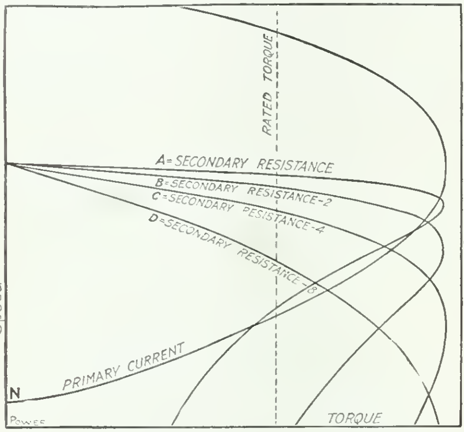

FIG. 2. SPEED-TORQUE CURVES FOR WOUND-ROTOR TYPE, WITH DIFFERENT SECONDARY RESISTANCES

SPEED CHARACTERISTICS

As the secondary voltage is that necessary to drive the secondary currents through the windings, it follows that the voltage required must depend upon the resistance of these windings. A larger resistance means a larger voltage for the required current and therefore a larger number of magnetic lines cut or a greater drop in speed. The torque being held constant, any variation in the secondary resistance requires a proportionate variation in the slip. If the slip with a given torque is 10 per cent., for instance, it will be 20 per cent. for double the resistance. The secondary resistance may be in the windings themselves, or may be external to the windings but part of the rotor body, or it may be entirely separate from the machine and connected to the windings by the proper leads.

Fig. 2 shows the speed-torque curves for a motor with different resistances in the secondary circuit. In curve *A* the secondary resistance is small and in curve *B* it is doubled. The maximum torque remains the same but the slip for any given torque is doubled. This motor starts much better than that in curve *A*. In curve *C* the resistance is again doubled and the slip is also doubled. The starting torque at rest is increased but the slip at rated torque is rather large. In curve *D* the slip is again doubled. The torque in this case is high at starting but falls rapidly as the speed increases. All the curves have the same maximum torque. So far as torque is concerned curve *D* is the best for starting. But for running curve *A* gives the least drop in speed. Consequently if a resistance is introduced at starting that will give the speed-torque *D* it should be cut out or short-circuited for the running position.

A current-torque curve plotted on the same figure will help to show the relations of starting to running currents with the secondaries of differing resistances. Beginning at the point *N* of no load or zero torque, the curve rises quite uniformly until the maximum torque is approached. Beyond this the current increases as the motor tends to slow down and stall. The upper portion of the curve corresponds to the starting period. Comparing the different curves it will be seen that *A* takes the most current at starting and gives a low torque; *B* takes less current and gives more torque; *C* takes less current than *B* and *D* less than *C* and delivers maximum torque at starting. From these curves it is evident that a high resistance rotor or secondary circuit gives the highest starting torque with the least current demand. Therefore, for a given torque there is no difference as far as current is concerned, the curves all having the same current for the rated torque, but operating at different speeds. As horsepower is proportional to torque and speed it will be seen that, although the current demands are the same the output is proportional to the speed. Thus motor efficiency and speed regulation are intimately related.

The secondary circuits of the majority of induction motors are of so-called "squirrel-cage" type, consisting of a series of heavy bar conductors passing through the rotor slots with their ends connected to a short-circuiting ring. This type has the advantage of extreme simplicity and absence of any form of brushes or contactors. It can only be used, however, for motors having speed-torque characteristics similar to curves *A* and *B*, Fig. 2.

When a motor is desired to give heavy starting torque with low current as in curves *C* or *D*, it is necessary to arrange the conductors on the rotor in separate circuits, usually three-phase, and to short-circuit them through a resistance connected within the rotor and manipulated by an external lever or to bring the terminals of the circuits to collector rings mounted on the shaft. Upon these rings brushes bear, which lead to secondary resistance grids placed external to the machine. It must be noted that the rotor currents are heavy and if the rotor resistance is to be made high, there will be a considerable loss of energy appearing as heat. As only a moderate amount of heat can be well radiated from the motor itself it is necessary to provide high-resistance secondary motors with external resistance.

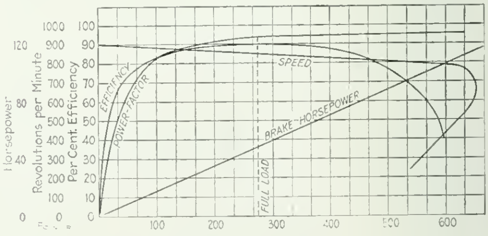

FIG. 3. CHARACTERISTICS OF SQUIRREL-CAGE MOTOR

Fig. 3 gives a set of typical characteristic curves of a squirrel-cage induction motor. In a general way the characteristics are similar to those of a direct-current shunt-wound motor. The speed regulation is good up to a point materially beyond full load. At $2\frac{1}{4}$ times full load, the motor reaches its "pull out" torque, at which point it will stall.

This motor has an improved power factor when operating on the heavier loads, the best point being above full load. The effect of a low power factor upon a motor circuit is to injure the voltage regulation as well as require more copper in the wiring.

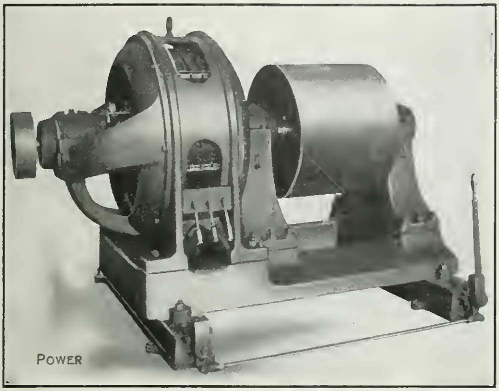

Fig. 4. Typical Synchronous Motor

External resistance or slip-ring motors have characteristics corresponding closely with those of compound-wound direct-current motors. The efficiency falls off more rapidly, however, with an increase of load.

Returning to the speed-torque curves in Fig. 2, it is seen that the speed under a given load depends upon the rotor or secondary resistance. By changing this resistance in external-resistance slip-ring motors, it is possible to change the load speeds materially. The maximum possible speed is slightly below synchronous speed with all resistance cut out and this may be reduced about 50 per cent. by the insertion of resistance. The drawbacks to this system of obtaining variable speed are the same as those of direct-current motors with armature control. The speed fluctuates widely with a change of load and the system is inefficient. It is not suited to machine-tool or similar work.

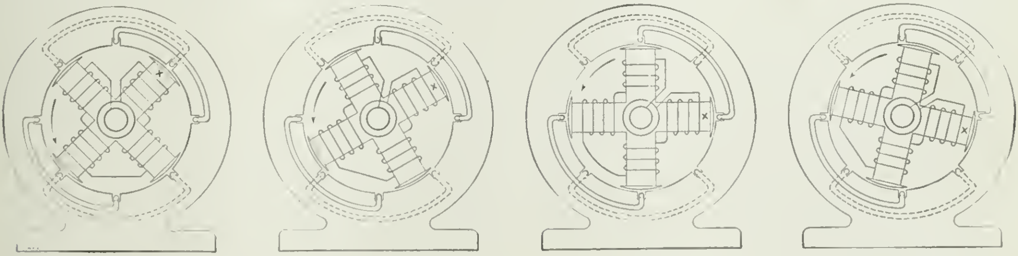

Fig. 5 Fig. 6 Fig. 7 Fig. 8

Current Actions in Synchronous Motor

It is possible to change the speed of an induction motor by changing the primary voltage. A reduction of voltage greatly reduces the torque, however, and a high resistance rotor is required together with a motor having a small air gap and very little magnetic leakage. Moreover, the speed fluctuates with the load just as in the variable rotor-resistance method and the efficiency is reduced with the speed.

It was seen that the speed of the primary magnetic field was dependent upon the number of poles in the rotor. Motors are built with provisions for changing the pole grouping and thus changing the speed. This method is practical only for small sizes. There is no alternating-current motor on the market having adjustable-speed characteristics similar to the direct-current shunt motor with field control.

SYNCHRONOUS MOTORS

The simple synchronous motor is almost identical in construction with the ordinary revolving-field alternator. It is usually built for polyphase currents and in the larger sizes. Fig. 4 shows a typical machine of this type. The stator is practically identical with that of the ordinary induction motor, grouped windings in the laminated stator setting up a rotating magnetic field. However, instead of placing in this field a drum carrying closed conductors, there is placed a set of radial electromagnetic poles, the arrangement of which is shown in Fig. 5. Due to the rotor magnetism acting upon the stator conductors carrying current, a torque is exerted and causes the rotor to revolve. It might appear that the greatest torque would be exerted when the rotor poles are directly under the stator poles at the instant they receive the maximum current in the cycle: this is not the case, however. Due to the rotor magnetism cutting the stator conductors, a counter electromotive force is generated in the latter, which is opposed and nearly equal to the impressed voltage, and the rotor lags a trifle. The counter electromotive force does not reach its maximum value in opposition until the rotor poles arrive under the stator poles, at which time the impressed voltage is already decreasing. There is thus a phase difference between the two voltages, giving rise to a resultant voltage which forces through the stator a current and thus produces a torque by reaction upon the rotor magnetism. If the load increases further the rotor will lag more, allowing a greater phase difference hence a greater current and greater torque.

In the foregoing, the rotor field current has been considered constant. Variation of the field current will now be taken up. It was evident that the rotor will always assume such a position that the phase difference between the impressed and the counter voltage is sufficient to allow a load current to flow through the stator coils just sufficient to produce the torque demanded. If the field current be increased the rotor magnetism will increase, thus increasing the counter voltage. The rotor will then drop back until the increased counter voltage is further out of phase with the impressed voltage, thus maintaining the load current and torque. This may be viewed in another way if it is noted that when the rotor and stator have the position of Fig. 6, the magnetizing effect of the stator current favors the rotor field, while in position of Fig. 7, the stator effect is in opposition to the rotor field. Thus if the rotor has a weak field it will assume some such position as in Fig. 6, in order that the magnetism may be maintained, retaining the counter voltage at the proper value to apportion the load current to the demand. If it has a strong field it will act in the opposite manner.

This brings out the fact that if the rotor-field strength is varied, the stator exerts a magnetizing effect to adjust the magnetism, counter voltage and consequent load current and torque to the proper values to maintain equilibrium. Now this magnetizing effect is caused by a magnetizing component of the current intake. It has been previously stated that the magnetizing current always lags 90 degrees behind the voltage causing it. Hence the amount of lagging current received by the motor depends largely upon the field strength of the rotor. In the case of Fig. 7, the rotor field is neither magnetized nor demagnetized, being merely distorted; there is thus practically no lagging current. In the case of Fig. 8, the magnetizing current has a negative value. It lags behind the counter voltage and is reversed in phase or leads with respect to the impressed voltage.

To summarize: For load there is a definite load current in phase with the impressed voltage which represents the actual power input; this represents the output plus the losses. There is in addition a magnetizing current 90 degrees out of phase with the impressed voltage which maintains the magnetism at the proper value to develop the torque required. The magnitude of this current depends upon the strength of the rotor field current. The total current taken is the resultant of these two components. It is evident that for a given load the current intake may be varied over a wide range by varying the field strength. With a weak field, a heavy current is drawn mostly lagging. As the field strength is increased, the amount of lagging current, hence the total current decreases and comes more nearly in phase with the voltage. At one value of field current there is no lagging current, hence the total current intake is a minimum and the power factor is 100 per cent. As the field is strengthened, the current again increases, a portion now being leading. With extreme values of field strength it is possible to obtain excessive current intakes due to the heavy magnetizing components.

All induction motors draw more or less lagging current from their supply circuits. In order to neutralize the effect of this lagging current an over-excited synchronous motor is often used in connection with large installations of induction motors. If a synchronous motor be used in this way with a heavy leading current its actual power output must be materially reduced. Ordinarily it is figured that the motor shall deliver about 50 per cent. of its rated capacity in power delivered at the shaft.

The heating of the motor is proportional closely to the total current intake and if a large component of leading current is introduced the power component must be reduced. The rotor field current cannot be reduced too much, due to instability. It was shown that the effect of additional load is to cause the rotor to lag. This decreases the favorable magnetizing effect of the stator and beyond a central point the effect is remagnetizing. If a motor with a weak field reaches this point, it will evidently lose magnetism, hence torque, and become stalled more quickly. If the field be heavily magnetized it can operate at a greater angularity in the demagnetizing quadrant before losing its magnetism and torque.

A source of direct current is necessary in order to magnetize the poles of the rotor. For this purpose, a small direct-current generator or exciter is commonly mounted on the motor shaft extension or belted thereto. This exciter is usually rated at about 5 per cent. of the motor capacity.

A synchronous motor drawing a leading current at one load may draw a lagging current at another, the proper excitation changes with the load. Therefore, this type of motor requires intelligent care and attention for its successful operation.

Starting Motors

These motors are started either by means of a small induction motor, usually mounted on the same shaft, or by induction-motor action in the motor itself, brought about in most commercial machines by placing copper conductors in the field-pole faces and connecting them with short-circuiting rings just as is done in the squirrel-cage induction type. They are usually started under reduced voltage to decrease the inrush of current and the field circuit is left open until the motor attains full speed. At the instant of starting a high voltage is induced in the field coils by transformer action. In some cases the field circuit is so arranged that it can be divided into sections during the starting period to reduce the total voltage generated; otherwise the coils must be well insulated.

Small squirrel-cage induction motors, five horsepower and below, are ordinarily started by throwing them directly across the line. During the accelerating period, a heavy rush of current occurs, three or four times full-load current usually. To prevent the fuses blowing at starting, a double-throw switch is provided, fused on one side only. The motor is started by throwing the switch to the unfused side and when it has attained full speed, the switch is thrown to the fused side which is ordinarily fused for 1½ times full-load current. A spring device is provided on switches of this type to prevent leaving the switch on the starting position.

Large squirrel-cage motors are usually started under reduced voltages to decrease the rush of current and to lessen the mechanical strain on the motors and machinery. The voltage reduction may be accomplished by the insertion of resistance in the primary circuits or by means of an autotransformer. The purpose is only partially accomplished by the resistance method as the useless loss in resistance at starting increases the current demand during the accelerating period. Autotransformers are arranged with several taps allowing a selection of starting voltages according to the torque desired. The torque of an induction motor varies as the square of the voltage. Hence for heavy torques comparatively large starting voltages are required.

Some motors are arranged for so called "star-delta" starting. Six leads are taken from the motor to the starting switch. During the starting period the windings are connected in star, which reduces the voltage impressed on each phase. When the motor attains full speed the starting switch is thrown to the delta position, in which the full line voltage is impressed upon each phase. This method is not suited to the starting of heavy loads as there is no selection of starting voltage and the motors can only be arranged to exert a comparatively low-starting torque. Also the design of the windings has to be sacrificed in some respects to adapt them to the double connection.

Slip-ring motors are usually furnished with drum-type controllers. They are arranged to start with maximum resistance inserted in the secondary circuit. The resistance is then reduced until the motor assumes the desired running speed.

Both squirrel-cage and slip-ring motors may be started by means of remote-control panels similar in appearance to those used for direct current. Controllers of this type are largely used for elevator service and for automatic control systems such as pump motors provided with a float switch in the relay circuit.

Multispeed motors are provided with drum controllers for changing the connections of the windings to obtain the various pole groupings.

Synchronous motors ordinarily require the use of a switchboard-control panel. This is provided with switches, a starting compensator of the induction-motor type, rheostats for the motor and exciter fields, voltmeter, ammeters and possibly a power-factor indicator.

* *

Turbine-Driven Centrifugal Pumps for Water-Works

By George H. Gibson

SYNOPSIS—An analysis of the reasons why a steam-turbine-driven centrifugal pump, especially for water-works systems, is better than a reciprocating engine-driven crank- and flywheel pump. The author considers first cost, overhead charges, obsolescence of equipment, foundations and buildings, steam cost, pumping duties, maintenance and general conditions affecting the attendance of both kinds of pumps.

*

The choice of pumping equipment for large water-works is practically restricted to two types, the triple-expansion crank-and-flywheel pumping engine and the steam-turbine-driven centrifugal pump. Such simpler types of reciprocating pumps as compound crank-and-flywheel and triple-expansion direct-acting pumps with compensating devices, engine-driven centrifugal pumps cost more than the turbine-driven centrifugal.

The total cost of pumping water may be divided into (1) steam costs, (2) interest and depreciation charges on machinery, foundations and buildings, and (3) expense for attendance and supplies. As regards steam costs, the triple-expansion crank-and-flywheel engine holds to date the record for duty. As an offset to high duty, the centrifugal pump offers lower first cost (hence lower annual charges), lower cost for foundations and building (as the unit occupies only about one-third to one-half the floor space and weighs much less) and less expense for supplies, such as packing, oil, waste, etc., together with greater simplicity and fewer parts, which tend to decrease the cost of repairs, replacements and attendance, notably the latter.

To illustrate how the higher steam rate of the turbine is compensated for by its lower fixed charges, assume that the head to be pumped against is 200 ft. The cost of a triple-expansion reciprocating pumping engine of large capacity for this head is approximately $3500 per million gallons daily capacity, while the cost of a steam-turbine-driven centrifugal for the same head will not be over $1000 for the same capacity. Taking the interest and depreciation charges to be 10 per cent. in each case, it will be seen that each million gallons daily capacity of the high-duty reciprocating engine must carry an annual charge of $350, whereas the centrifugal pump will be required to carry only $100, leaving $250 available to pay for any difference in steam consumption. If the average duty of the reciprocating pumping engine be assumed at 170 million foot-pounds, as against 130 million for the turbine unit, the yearly cost for steam, 16 hours per day with coal at $3 per ton, will be $13.08 per water horsepower for the reciprocating engine, as against $17.10 for the turbine-driven centrifugal pump, or a saving of $4.02 per year for each water horsepower capacity installed. Pumping at the rate of one million gallons per day against 200-ft. head corresponds to about 35 water horsepower, upon which the yearly saving of $4.02 would amount to $140.70. Subtracting this from $250 saved by the turbine-driven centrifugal pump on fixed charges, leaves $109.30 for each million gallons daily capacity in favor of the steam-turbine-driven centrifugal-pump unit.

The turbine-driven centrifugal pump maintains its duty better than does the reciprocating pump, as there are no adjustments and but few parts subject to wear, and will usually save about one-half the cost for attendance, except in small plants, where only one man is required.

With the reciprocating pump there is a continual expense for valves and packings, neither of which enter into the cost of upkeep of the turbine and centrifugal pump. The expense for oil and waste of the former is also considerable, while with the turbine it is negligible, since the latter employs a closed oiling system using the oil over and over. Cylinder oil, which is a heavy expense with large multiple-cylinder reciprocating engines, is not used in the turbine. In addition, there are many minor supplies, such as gaskets, small packings, etc., which must be kept in stock for the reciprocating pump, but are required very little or not at all by the turbine unit.

The life of machinery is frequently figured at 20 years, requiring 3.23 per cent. to be charged off per year to a sinking fund drawing interest at 4 per cent. Some engineers have assumed a higher percentage or rate of depreciation on steam-turbine-driven pumps than on reciprocating pumps for the same conditions, but the yearly cost of maintaining turbine-driven centrifugal-pumping equipment is no greater in percentage of first cost than is the yearly cost of maintaining reciprocating equipment.

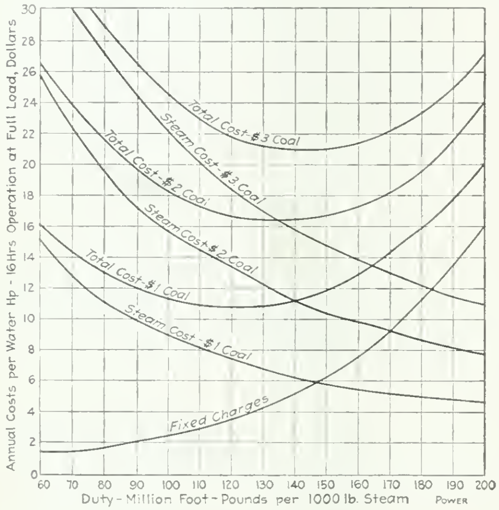

FIG. 1. COSTS PER WATER HORSEPOWER

The depreciation on machinery is often figured at a higher rate than that on buildings and foundations, and while it may be true that the latter will last longer than machinery, so far as natural wear and tear are concerned, it is not correct economically for the reason that when the machinery has outlived its usefulness or has become obsolete, the buildings and foundations, and in fact, the entire equipment, is often obsolete and must be torn down and replaced. Changing conditions may require removal or abandonment of the plant, as where the water supply has become contaminated or insufficient filtering equipment is available, etc. Old buildings are seldom available for new equipment, although in perfect condition and repair. In any case, depreciation on foundations should be equal to the charge on machinery, for the reason that it is seldom that old foundations can be used for new apparatus, or at least not without considerable remodeling, at an expense equal to that of new foundations.

The difference between the costs of the foundations and buildings for steam-turbine-driven centrifugal pumps and those for reciprocating pumps is in favor of the steam-turbine unit. Large and expensive foundations are required for reciprocating pumps, not only because of the great weight of the machine, but also to resist the vibration and strains due to unbalanced reciprocating motion. The steam-turbine-driven pump requires a comparatively small building with but little headroom, and of comparatively light construction, as the parts to be handled by cranes are small, while the reciprocating pump requires large, high buildings, substantially built to support cranes of large capacity. Where the conditions for foundations are bad, the advantages of the centrifugal pump become still greater.

The fixed annual charges on pumps increase with the duty and at a rapidly increasing rate, as shown by the lower curve in Fig. 1. The minimum total pumping cost is found where the sum of the annual charges and steam cost is a minimum, which is also the point where the slope of the fixed-charges curve is equal and opposite to the slope of the steam-cost curve. The minimum cost of pumping is not necessarily at the point where the two elements of cost are equal, but may be found at a point where the annual charges are still considerably less than the steam cost. The curve shown for annual charges is based on recent quotations on pumping engines. In a specific case, the chart has little value further than for a preliminary sizing up, as the decision must be based on definite prices and guarantees submitted on the individual installation. The turbine-driven centrifugal pump, however, has the advantage for all prices of coal up to about $6 per ton.

Under practical working conditions, the turbine-driven centrifugal pump often nearly equals in duty the triple-expansion, crank-and-flywheel pumping engine, particularly if the average duty, as affected by wear and slippage, and also the greater ability of the turbine pump to make profitable use of high steam pressures, high superheats and better vacuums be considered. The steam turbine can utilize high-pressure and superheated steam without the lubrication troubles encountered by reciprocating engines.

The reciprocating engine shows little improvement with increase in vacuum above 25 or 26 in., but the steam turbine is able to take care of the very much greater temperature range which high vacuums supply. For example, in a pound of steam expanded from an initial pressure of 150 lb. to 25-in. vacuum, there are available for conversion into work 234 heat units, an increase of 45 per cent. While the steam turbine is able to turn a larger proportion of this heat made available by higher vacuum into increased duty, the reciprocating engine shows little, if any, improvement. As a general statement, it may be said that for a pumping unit having a capacity equivalent to 700 water-horsepower or over, and with standard turbine steam conditions, the turbine-driven centrifugal pump can be made to show a duty of over 150 million foot-pounds per 1000 lb. of steam.

It should be borne in mind that duty guarantees based on plunger displacement are of little value, because of slippage. For example, in one of the largest municipal water-works, where a force of men is employed solely to measure the duties of pumping engines, slippages as great as 15 to 30 per cent. are occasionally found. A slippage of 2 or 3 per cent. is disregarded, and an engine is not overhauled until the slippage exceeds 4 per cent. Asuming the duty of an engine based on plunger displacement to be 170 million foot-pounds per 1000 lb. of steam, this at once reduces the duty to 163.2 millions. In other words, a reciprocating pumping engine showing 170 millions duty measured by plunger displacement and having a slippage of 4 per cent. would probably be doing no better, as measured by work delivered in the water, than would a centrifugal pump having a duty of 162 millions.

The Turbine Centrifugal-Pump Problem

The problem of directly connecting the steam turbine to drive the centrifugal pump arises from the great disparity between the spouting velocity of steam and the peripheral velocity required of the pump impeller. For a turbine developing about 1000 shaft-horsepower, the ideal speed is between 4000 and 5000 r.p.m. To reduce the speed below this with a given number and size of wheels will cause the duty of the turbine to fall off because of high velocity in the steam as it leaves the buckets, while to reduce the speed by adding more stages will increase losses by steam friction unless the diameters of the wheels be reduced, which reintroduces leakage and leaving losses. The use of a large number of stages also increases the first cost of the turbine.

Fig. 2 shows the relation between delivery and efficiency when pumping against a constant head, the delivery being controlled by varying the speed.

Suppose a 1000-hp. turbine operating at 4500 r.p.m. is to be directly connected to a centrifugal pump delivering water against a head of 200 ft. The peripheral velocity required of the impeller will be about 115 ft. per sec., and as the capacity of the pump will be about 15,000 gal. per min., the speed will be approximately 1000 r.p.m., that is, about one-fourth of the turbine speed. By using two pumps, each of half the capacity, this speed can be increased in the ratio of the square root of 2 to 1, or 1.4; 1.4 times 1000 is 1400 r.p.m.. Or by using three impellers in parallel, it may be increased in the ratio of the square root of 3 to 1, or to 1730.

As this is still considerably short of the best turbine speed, the only remaining alternative, if the turbine is to drive the pump directly, is to compromise between the two speeds—that is, reduce the turbine speed and increase that of the pump. The speed of the turbine may be reduced by adding more stages, and by running below the most favorable speed for the given number of stages.

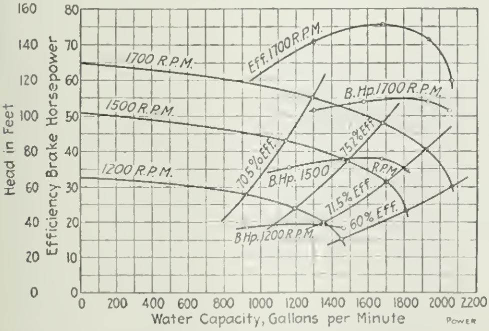

Fig. 2. Relation between Delivery and Efficiency When Pumping against Constant Head

The pump speed may likewise be increased by increasing the entrance velocity and using a smaller impeller. Each has a detrimental effect upon the respective efficiency.

As for the pump, the increased velocity of entrance is secured at the expense of the suction head and this velocity head must be reconverted into pressure head at the delivery. Inasmuch as this reconversion is not perfect, an additional loss of work is imposed upon the pump over what would be necessary were a normal entrance velocity used. Obviously, this method of increasing the speed is the more unfavorable the less the total head to be overcome. For moderate and large capacities this compromise involves the use of several impellers operating in parallel and running at high speed with high water velocities, which is apt to introduce mechanical and hydraulic unbalancing and vibration, with consequent pitting and erosion, necessitating frequent renewals.

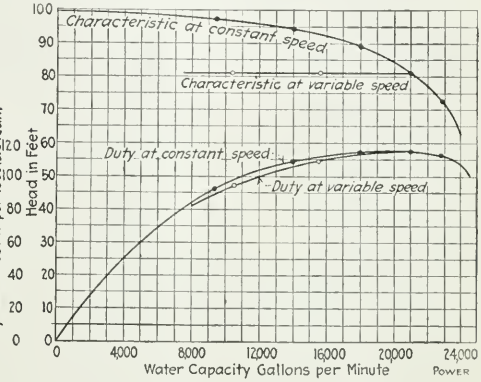

Fig. 3. Duty as Affected by Speed

The solution of the speed problem which has been most successful is the use of a mechanical speed-reducing gear between the turbine and the pump. This permits of running each member of the unit at its most favorable speed, having regard solely for its own characteristics. If the turbine be operated at the speed corresponding to its maximum efficiency, it is possible to vary the speed considerably while affecting the steam economy very little. This feature is useful where a pump is to be operated at different rates of delivery, as will be apparent from Fig. 3.

*

Test of J-M Boiler Preservative

Dr. C. E. Ford, commissioner of the department of public welfare, Cleveland, Ohio, recently made a laboratory test with J-M boiler preservative. He determined that no danger whatever existed from its being carried over with the steam, and furthermore, even if the preservative were to carry over, there would be no contamination of food products, if the steam were used for cooking, as it is composed of natural, harmless salts extracted from the sugar beet.

This preservative is the enemy of boiler scale, its action being partly chemical and partly mechanical. On account of its strong affinity for iron, it works its way through the cracks of the scale, causing it to loosen and drop off when the boiler is blown off or washed out.

It is also used to neutralize the acid properties of feed waters and to bring the alkalinity test up to the point at which corrosion and pitting will stop. It forms a thin coating on the iron and, when used regularly, prevents scale-forming elements from adhering to the metal.

The preservative is manufactured by the H. W. Johns-Manville Co., New York City.

Down-Draft Heating Boilers*

By Osborn Monnett†

SYNOPSIS—Typical heating boilers and designs of furnace for smokeless operation. Ringelmann chart readings from these boilers show good results.

⁂

Being peculiarly adapted to low rates of combustion, the down-draft grate works out well for heating loads. Although with some types of equipment it is not possible to get the long flame travel obtained in power boilers, still the infrequent intervals between firing insure a good supply of coked coal on the upper grate, which, if carefully poked down, need not make any smoke. The secret of success with this type of furnace is to carry a thick, heavy fire on the upper grate in order to accumulate as much coked coal as possible before poking.

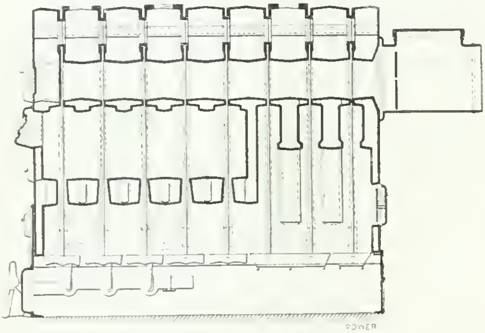

Fig. 1. American Radiator Co.'s "Ideal" Boiler

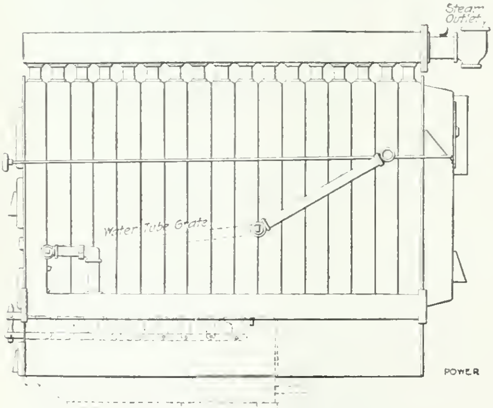

Fig. 2. Hart and Crouse Royal Boiler

A number of types of down-draft boilers for low-pressure work are shown in Figs. 1 to 6. Figs. 1 and 2 show two types of cast-iron boiler, one having the down-draft water grate cast in the section of the boiler and the other a water-tube grate made up between headers in the ordinary way.

Figs. 3 and 4 illustrate the firebox type of down-draft boiler, the difference in the construction of the water grate being plainly shown. Two styles of uptake are shown, either of which can be used with either boiler.

Fig. 5 shows a Herbert detachable down-draft furnace installed in connection with a return-tubular boiler, with a two-span deflection arch for gas mixture. Another interesting setting of the same type is shown in Fig. 6. It consists of an Evans-Almirall hot-water installation made up of a typical down-draft grate under a 54-in. by 14-ft.

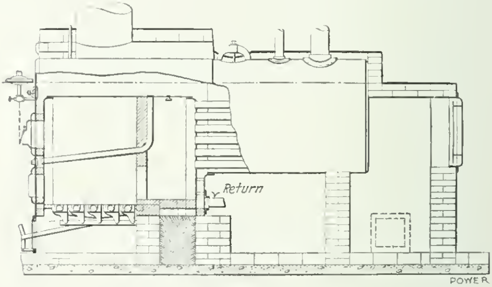

Fig. 3. Brennan Firebox Down-Draft Boiler

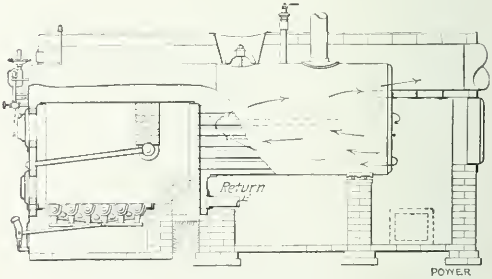

Fig. 4. Kewanee Firebox Down-Draft Boiler

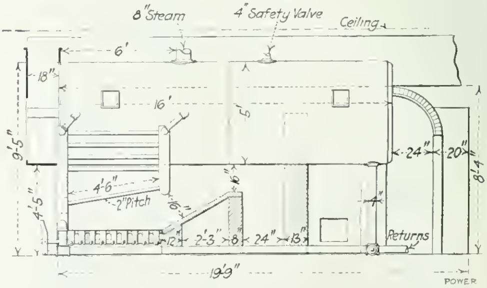

Fig. 5. Herbert Detachable Down-Draft Furnace under 60-In. by 16-Ft. Return-Tubular Boiler

return-tubular boiler. In the combustion chamber is fitted a V-pier and wing walls similar to the No. 8 furnace previously described. This makes a good combination to use whenever the return-tubular type of boiler is employed. The areas are worked out the same as for the power boilers previously described.

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*Copyright, 1914, by Osborn Monnett.

†Smoke Inspector, City of Chicago.

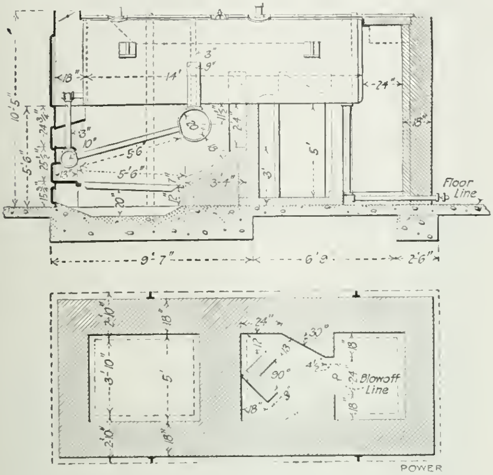


FIG. 6. EVANS-ALMIRALL DOWN-DRAFT BOILER WITH V-PIER AND WING WALLS

TABLE I. RESULTS FROM DOWN-DRAFT HEATING BOILERS BURNING ILLINOIS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	240	42.5	3.5
2	240	16.5	3.8
3	240	37.0	3.0
4	240	73.5	6.1
5	240	61.5	5.1
6	240	63.25	5.2
7	240	51.5	4.3
8	240	45.5	3.8
9	240	20.75	1.7
10	240	112.0	9.4
11	389	67.5	3.4
12	180	29.0	3.2
13	240	96.0	2.0
14	240	5.25	0.4
15	240	26.0	2.2
16	240	67.25	5.6
17	240	20.25	1.7
18	240	20.0	1.6
19	240	00.0	0.0
20	240	42.0	2.0
21	240	87.75	7.8
22	240	21.5	1.8
23	220	99.0	9.0
24	240	18.0	1.5
25	240	00.0	0.0
26	240	58.5	4.9
27	240	00.0	0.0
28	240	135.5	11.2
29	240	23.0	1.9
30	240	19.75	1.2
31	240	36.5	3.1
32	240	58.5	4.8
33	240	6.0	0.5
34	240	50.5	4.2
35	240	00.0	0.0
36	240	00.0	0.0
37	240	71.5	5.9
38	240	00.0	0.0
39	240	66.5	5.4
40	180	5.5	0.6
41	180	00.0	0.0
42	180	6.0	0.6
43	240	8.0	0.6
44	240	41.0	3.4
45	240	86.75	7.2
46	240	00.0	0.0
47	240	60.0	5.0
48	240	11.0	9.0
49	240	0.5	0.1
50	240	84.25	7.0
51	240	67.0	5.6
52	240	7.25	0.6
53	240	15.25	1.3
54	240	00.0	0.0
55	240	102.25	8.5
56	380	39.5	2.6
Total	13,649	2244.5	3.28

A series of Ringelmann chart readings were taken in Chicago during the past heating season on down-draft boilers using various fuels and on plain firebox boilers using Pocahontas coal. The results are tabulated herewith. Bearing in mind that from 2 to 5 per cent. is considered a satisfactory performance for hand-fired boilers, it can be seen how near the ideal was approached by the average of all the readings taken.

TABLE 2. RESULTS FROM DOWN-DRAFT HEATING BOILERS BURNING POCAHONTAS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	240	15.0	1.2
2	240	1.5	0.1
3	240	7.5	1.5
4	240	9.25	0.8
5	240	48.5	4.0
6	240	39.0	3.25
7	240	00.0	0.0
8	360	5.0	0.3
9	240	54.75	4.5
10	240	52.0	4.3
11	240	2.75	0.23
12	240	3.5	0.3
13	240	5.5	0.4
14	240	5.0	0.3
15	240	2.0	0.2
16	240	29.0	1.9
17	240	3.0	0.3
18	240	67.24	5.6
19	240	00.0	0.0
20	240	14.25	2.1
21	240	3.0	0.3
22	180	3.0	0.3
23	240	17.25	1.4
24	240	16.5	1.3
25	240	19.5	1.6
26	390	18.0	0.9
27	240	5.0	0.4
28	240	0.0	0.0
29	240	0.0	0.0
Total	7170	441	1.2

TABLE 3. RESULTS FROM CAST-IRON AND FIREBOX TYPES OF BOILER, UP-DRAFT, BURNING POCAHONTAS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	225	15.75	1.4
2	240	39.5	3.3
3	240	42.25	3.5
4	240	25.0	2.1
5	240	8.25	0.7
6	240	17.0	1.4
7	240	7.5	0.6
8	240	0.0	0.0
9	240	31.0	2.5
10	240	0.0	0.0
11	240	16.25	1.3
12	240	55.25	4.6
13	240	149.25	12.4
14	240	160.25	13.3
15	240	53.0	4.4
16	240	0.0	0.0
17	240	18.75	1.1
Total	4065	539	2.7

The data were collected without the knowledge of the operators of the various plants, who were in every case the ordinary janitor found on heating jobs. When the density ran higher than 5 per cent., it was always due to carelessness. Education will be a big factor in getting better results from this type of equipment when it becomes more generally introduced.

⁂

Natural Gas Output in 1913 in the United States was the greatest in the history of the industry, surpassing that of any previous year in both quantity and value. The total gas production in 1913 is estimated by B. Hill, of the United States Geological Survey, at 581,898,239,000 cu.ft., valued at $87,846,677, an average price of 15.10 cents per thousand cubic feet, as compared with a production of 562,203,452,000 cubic feet, valued at $84,563,957, an average price of 15.04 cents, in 1912, the increase being 19,794,787,000 cubic feet in quantity and $3,282,720 in value. Of this total product, about 32 per cent. was utilized for domestic purposes, or 184,885,662,000 cubic feet, valued at $50,522,415, an average price of 27.33 cents per thousand cubic feet, and 68 per cent. was utilized for industrial purposes, or 397,012,577,000 cubic feet, valued at $37,324,262, an average price of 9.4 cents. The industrial consumption includes gas used for both manufacturing and producing power.

West Virginia led in quantity of natural gas produced and Pennsylvania was second, Pennsylvania was the leading state in quantity of natural gas consumed, and Ohio second.

Recovery of Gas-Engine Waste Heat

SYNOPSIS—By maintaining a rapid circulation through the jackets, the temperature of the water can be raised sufficiently high to produce steam at 25 to 50 lb. without danger of overheating the cylinders. In this way all the heat ordinarily wasted to the jackets is utilized in the form of low-pressure steam.

⁂

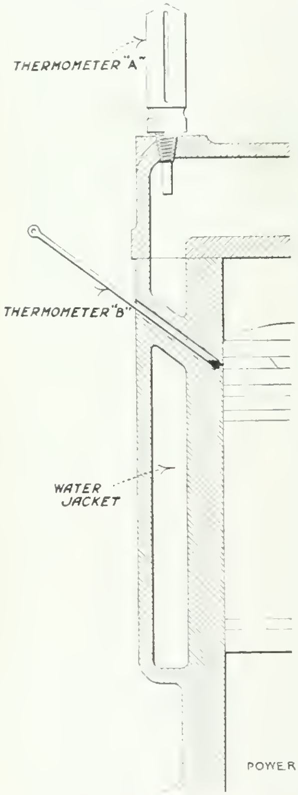


Fig. 1. Method of Measuring Temperature Drop through Cylinder Walls

In competition with steam engines, the gas engine has long suffered a handicap where the conditions have demanded low-pressure steam for heating or industrial purposes. While some progress has been made toward utilizing the waste heat for this purpose, the practice has not been general, one obstacle being the difficulty in raising the jacket water to a sufficiently high temperature without danger of overheating the cylinder.

Recent investigations by J. B. Meriam, of the Bruce-Macbeth Engine Co., indicated that when the jacket-water temperature is raised above 150 deg., bubbles begin to form and adhere to the surface of the iron. These increase in size and number with a rise in temperature until at 200 deg. the entire surface is covered with bubbles. Closer inspection showed that each bubble spreads out where it comes in contact with the iron, preventing the water from coming in contact with the surface and thus acting as a heat insulator; hence, a dangerous rise in temperature of the cylinder walls.

By forcing the water in a closed circuit through the jackets at high velocity (five to ten times normal) it was found that the temperature could be raised to at least 300 deg. (corresponding to about 50 lb. steam) without danger to the cylinder; showing that at this high velocity the insulating bubbles did not have a chance to cling to the iron.

As further proof a cylinder was provided with a boss as shown in Fig. 1, and a $\frac{5}{16}$-in. hole was drilled at an angle to within about $\frac{1}{16}$ in. of the inner surface. A drop of mercury was placed in this hole and a thermometer *B* inserted. A second thermometer *A* was then placed in the jacket as shown. It was found that the difference in temperature as recorded by the two thermometers was practically constant over a wide range of jacket-water temperatures, showing that the heat was carried away by the water as fast as it passed through the cylinder walls. In this particular engine used in the test it was found to require a little less than 30 min. to raise 10 lb. steam pressure.

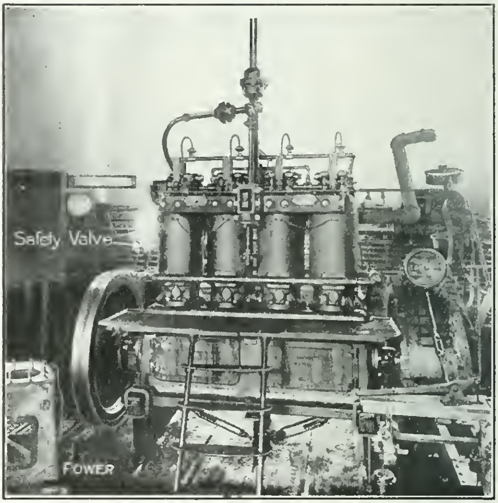


Fig. 2. Engine on Testing Floor

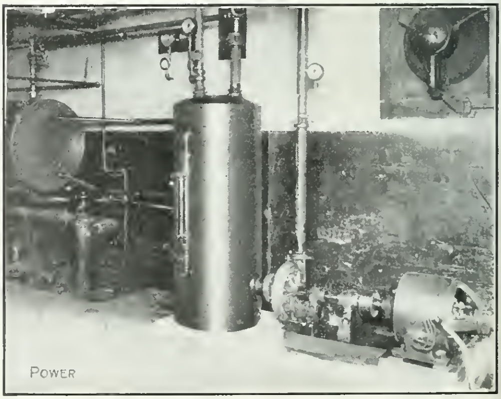


Fig 3. Part of Installation at Younglove Building

The distribution of heat in an efficient gas engine is about as follows:

	Per Cent.
Effective work	27
Radiation	3
Exhaust	38
Water jacket	32

It follows that if an inclosed cooling system is used, and only steam is allowed to escape, then all of the water used must eventually be turned into steam, and practically the entire 32 per cent. of the total heat of the fuel, referred to as lost to the jackets, is recovered in the form of steam.

With a well designed exhaust-gas boiler, about one-half the 38 per cent. of the total heat of the fuel which is lost to the exhaust should be recovered. This added to that recovered from the jacket water would make about 50 per cent. of the heat of the fuel available in the form of low-pressure steam. The engine on which the tests were conducted was equipped with a water-jacketed exhaust manifold (see Fig. 4), but without a specially designed exhaust-gas boiler, and it was found that the temperature of the exhaust gases leaving the engine beyond the water-jacketed manifold exceeded 950 deg. F. at full load.

The difference in temperature between the entering and outgoing water was less than 15 deg. and the cylinder was thus maintained at a practically constant temperature.

Another marked feature claimed for this process is increased thermal efficiency of the engine, so that the fuel consumed is about 2 per cent. less at maximum load and 15 per cent. less at quarter load. With an engine of high efficiency and operating at maximum load, there will be evaporated by this process approximately four pounds of water into steam at 25 lb. pressure per brake horsepower-hour delivered by the engine. As might be expected the quantity of steam generated per horsepower-hour increases as the load decreases, due to lower thermal efficiency and hence increased rates of fuel consumption at the lighter loads. On one of the tests an evaporation of 7.3 pounds of water per brake horsepower-hour was attained at quarter load.

Fig. 2 shows a Bruce-Macbeth engine equipped for this process, on the testing floor, and Fig. 3 part of the installation in the Younglove Building at Cleveland. Here there are three gas engines of 150, 60 and 30 horsepower, and one motor-driven centrifugal pump supplies the water at high velocity to the engines. Only one expansion tank is used. The horizontal tank shown is the hot-water supply for the building and is fitted with a steam coil, which receives its supply from the gas-engine jackets or from the low-pressure heating boiler in the next room. This allows the hot-water tank to be carried at full city pressure, while the jackets of the engine deal with low-pressure steam; in this case 5 to 10 pounds.

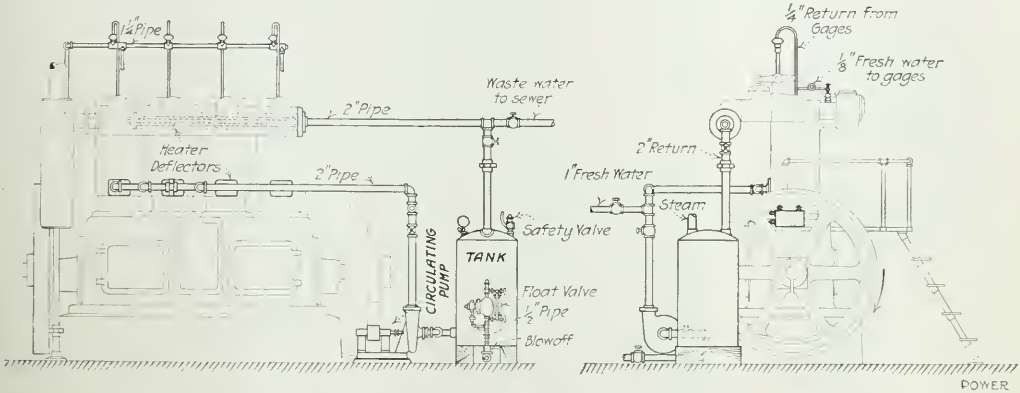


Fig. 4. Engine Equipped with Water-Jacketed Exhaust Manifold

Temperatures in the Locomobile

In the Feb. 18 issue, a sectional view of the apparatus and piping of a typical reciprocating-engine plant, operating condensing, was published. The illustration also showed the variation of temperature and pressure of the boiler gases and of the steam during the course from the boiler through the engine, condenser and back to the boiler.

On page 496 of this issue is shown a sectional view of a locomobile with the temperature reduction from 2500 deg. at the furnace to 105 deg. at the condenser discharge.

This illustration represents just as complete a power plant, boiler, engine, heater and condenser as that in the Feb. 18 issue; a unit up to 600 hp. in capacity would require about one-half the floor area. There is no external steam piping and the main engine drives all the auxiliaries.

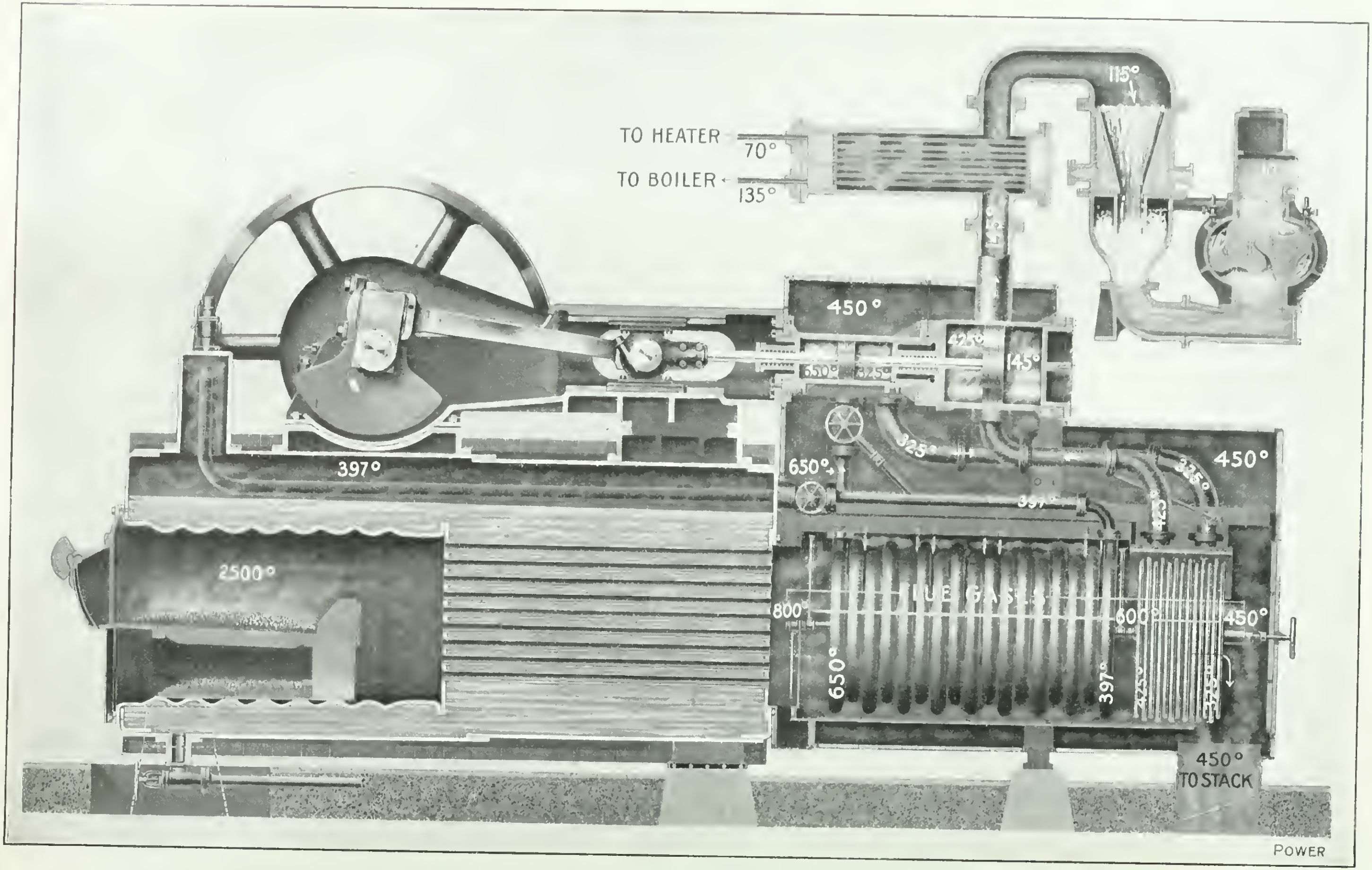
The heater and condenser are placed above the main unit to more clearly show the connection between them and the engine cylinders. With the ordinary unit the heater, pump and condenser are at the side of the boiler.

⁂

Isolated Power Plant for Coney Island—According to the latest report, Coney Island is to have another isolated power plant. Bids have been asked on a 2500-kw. capacity power and lighting plant, the main units to be turbo-generators. This plant will be constructed by the Luna Amusement Co., and will furnish power and lighting for Luna Park and its attractions.

⁂

Tool Rust Prevention—Tools that are used or stored in damp places can be kept from rusting by using the following protective coating: Get a half a pound of melted lard, stir in a half ounce of camphor, and skim off the scum; next add, constantly stirring, three ounces of finely powdered graphite, and apply the mixture hot to the tools after they have been cleaned and wiped dry. Any surplus of the grease can be wiped off after 24 hours with a cloth or clean waste.



Distribution of Temperature in the Locomobile

Showing how within this self-contained unit the temperature is reduced from 2500 degrees at the furnace to 105 at the condenser discharge.

Editorials

Appropriations for Smoke-Inspection Departments

Lack of money for city smoke inspection was a condition much deplored at the recent convention in Grand Rapids, Mich., of the International Association for the Prevention of Smoke.

It is difficult to make the citizens, and especially the majority of the officials seeking the support of the citizens, see that the smoke department is doing any real good. These people have no adequate conception of the nature of the work, and as soon as the department is created, all are angrily disappointed to find even one stack emitting the substance that a new ordinance, backed by a whole department, has been instituted to prevent. It is a pity that the citizens cannot be made to understand that the laws for smoke elimination are the most insignificant part of the whole thing. Mere laws will not stop smoke any more than they will complete the arrest of the offenders. It takes jails, police, patrol wagons, alarm systems, etc., to do the latter, and it requires changes in firing methods, remodeled furnaces, supervision of new construction, and much moral suasion, all of which requires time, before any really noticeable diminution of smoke occurs.

If a smoke-inspection department has competent engineers and has authoritative supervision over the design and installation of new furnaces as well as of repairs or changes to old ones the saving to individual users of fuel sometimes amounts to more than the entire appropriation to conduct the department, to say nothing of the saving to the city.

Another fact that must not be overlooked is that when the department has revised the boiler-room practice in a plant and has effected a saving to the owner, he becomes of value in helping to enforce the smoke ordinance. He informs his industrial friends of what the department has done for him, and soon, in an ever growing circle, the department is regarded as a boon instead of a pest with a legal right to existence.

To bring this condition about requires close attention by the department to individual cases. A plant that is a chronic smoker or one that becomes one after changes in coal, firing methods or settings, must be critically studied to find the cause, discover a remedy and then the owners must be persuaded to adopt it. Data concerning the case must be recorded, and an inspector must devote much time to the plant so that when similar cases arise, the department may know how to care for it.

The practice of making the smoke inspection departments of American cities one-man affairs, or nearly so, is altogether too common. In most cases, it is worse than foolish; it is pitiable ignorance or unpardonable negligence.

What is an appropriation of two, or twenty thousand dollars to reduce the cause of annual damage amounting to millions in most large cities?

Industrial Education

Much is being heard of the present being the accepted time for the United States to increase its prestige in the foreign markets. This is true, but so much of this kind of talk is likely to give the impression that this country has not figured to any extent in foreign trade heretofore. which is not so. The Bureau of Foreign and Domestic Commerce of the Department of Commerce has recently published a book, "The Commercial Relations of the United States," which shows by figures for 1912 that in that year the United States was the world's third largest importer, only the United Kingdom and Germany being ahead of it, while as an exporter this country had the lead.

So much by way of indicating that the United States has a position of importance in the world's markets already. This, however, does not deny the fact that the opportunity is here for it to gain additional foreign business, which, with the proper methods, it should be able to hold indefinitely, even after the disturbed conditions abroad may be adjusted.

One very important part in this desirable object may be played by industrial education. In this connection it is interesting to review something of the work that has been done by the National Association of Corporation Schools, as given in the report to the executive committee, abstracted on another page of this issue.

The association was formed with the idea, not of supplanting any existing forms of education or any established educational institutions, but with the hope of supplementing their work. The corporation schools do not pretend to carry along the educational courses given in the common or grammar schools, and they believe that these schools should have entire charge of the scholar until he is fourteen, or has been graduated from the grammar school. The association does not believe that the child should be taught any trade or be encouraged to select any specific industry until he is a grammar-school graduate; but it does believe that a knowledge of the industries and a broad general cultural knowledge could be taught the child between the ages of 12 and 14.

The association, now in its second year, has had enough experience to enable its executive committee to map out a constructive plan, to which the association intends to work prior to its third annual convention, which will be held in Worcester, Mass., during the second week of next June.

We believe that our readers will be interested in the report before referred to, and while the association's work is not confined to the field with which we are especially concerned, we believe that it can play a very important part in the field of power-plant engineering, as well as in other industries.

Any boost that can be given the good work by those whose attention may have been arrested by these words will be directed in a good cause.

The Market for Service

All markets are more or less regulated by supply and demand. Commodities of the highest grade usually netting the highest price and being the most readily disposed of, the market for engineering services should be a fruitful field for study.

The age is one of minute specialization. Not often is a successful engineering specialist a successful business specialist. The high-salaried man is the man who can control and direct men of genius. He is the expert broker in brain markets. That is his specialty. He makes no pretense to know engineering, but he sets the wages for engineers.

Without a market master genius is extremely liable to go derelict. The country is full of misfits. One customer is not enough to attend the market of a man's service. Competition is as needful among buyers of service as among sellers of it. Employers may have many avenues through which to get an engineer's services at their own figure. His hours are long; his days off are few. His need for employment is pressing and his fear of being out of work is great.

Let us suppose that his education has been his business; not marketing his services. All his efforts have been bent on one purpose. Fortunate indeed he is if he makes a satisfactory sale at first offering. Too often this is not the case. Intellectual giants often go about doing child's work. This is one type of misfit. The other is more hopeless. He is the man who, having spent little on his education and training, manages, by some means, to market his wares above their merit. He gets in; he bluffs; he fakes and hides his ignorance as long as he can. Then he goes down. In so doing, he does the profession more harm a hundred-fold than the first.

Let us presume that most employers are honest in their desires for the welfare of their engineers. The trouble is here again, that their "profession" has not been the "business" of *hiring* engineers. Their profession is that which causes them to *need* engineers. They are specialists, if successful in their vocation. They have been imposed upon by unscrupulous and lying vendors in the market of engineering service. They want good men as badly as good men want places. It is the bogus element that needs eliminating.

Over in the market gardening regions of New Jersey, a study has been made of soils and their adaptation to various crops is occupying the minds of specialists. For instance, in one section nobody raises anything but potatoes for miles around. Their undivided attention is given to producing, quantity, quality, economy of methods, etc. These men have to give little thought to selling, because they have a selling exchange. A marketman was selected and paid to make the selling his specialty. He must keep constantly in touch with the markets, and has become an expert business specialist.

The expert engineer needs a business expert just as much, and it might not be such a bad idea to have a business expert or a market commission or bureau keeping personal records of engineers, just as Uncle Sam has a record of every soldier in the old Ford Theatre Building in Washington. Such records would be as valuable to employers as to engineers. It would make for the elevation of the worthy, would weed out the unworthy and ultimately better the profession.

What Is Wrong in Jersey?

For nearly thirty years the engineers of New Jersey appealed to and demanded of the legislature at Trenton a license law for engineers and firemen. Local city ordinances were rightly scorned by nearly all and each year renewed effort was made to make the law a reality, for state supervision of this matter was deemed best and proves best wherever practiced. Its industrial importance made a state license law imperative in New Jersey, and thanks to the unremitting efforts of the engineers the legislature passed, though reluctantly, the last bill presented.

This law took effect on July fourth of last year—fifteen months ago. The law required that within sixty days after its enactment the Commissioner of Labor should organize a steam engineer's and boiler operator's license bureau. About July first of last year it was rumored that, as the bill passed during the closing hours of a special session of the legislature, no appropriation had been made, to carry out the provisions of the law, and therefore the bureau would not be organized until an appropriation was forthcoming.

Months later, on the reassembling of the legislature, the appropriation came and all that remained to be done was for the Commissioner of Labor to appoint the personnel of the bureau and have his appointments confirmed by the civil service commission. In the meantime, Commissioner Bryant was subjected to attack by politicians who wished to rob him of his powers. The attack was iniquitous and his friends, the engineers, publicly voiced their disapproval of the whole affair, and with their support and that of the press, Col. Bryant retained his department.

In view of this, there is a feeling of deep dissatisfaction among the engineers at the recent action of the Commissioner. He made the appointments, but he is insisting too strongly on playing a political game unbecoming his office to force his appointments through after two out of the three appointees have fallen "considerably below the usual passing mark" in their examination before the civil service commission.

Commissioner Bryant appointed three men, each representing one of the three leading engineering organizations in the state. Mr. Case, who acted as chairman for the license committee for the National Association of Stationary Engineers in New Jersey, was the only one to pass, and engineers are wondering if they must wait until the commissioner railroads the other two through, despite their failure to qualify, before the bureau begins its work. There are many engineers qualified for these positions who have the time necessary to give to the work. Let the commissioner select from among these before the legislature repeals the law at the coming session, as there is some talk of doing.

* * *

If the American Society of Mechanical Engineers' Code for boilers comes into general use, it will be possible to tabulate and classify quite completely, for all will be 55,000 pounds tensile strength.

* * *

Maximum efficiencies to the engineer are like the fixed stars to the mariner; though neither can be touched, they are invaluable as guides to the right way.

Correspondence

Incompetent Repair Men

In almost every community there is the usual repair shop where it is alleged that all kinds of machines are repaired by expert mechanics with neatness and dispatch. All too frequently these shops must be called upon by the engineer who does not even have a pipe cutter or die. Some of their blundering mistakes are ludicrous, to say the least.

In a certain small plant the engine was a 14x36 simple Corliss with V-guides. The engineer had the lower crosshead shoe rebabbitted at the repair shop, but the repair man accidentally dropped it on the cement floor, breaking off the lug for the adjusting screw.

He did not acknowledge the accident or take steps to make repairs, but in slipping the shoe into place he used a large washer under each jamb nut, by which the shoe was adjusted. As the crank side of the engine was near the wall on the dark side of the room, the missing part was not noticed for several weeks. The repair shop refused to furnish a new shoe for the one broken.

Some years ago I was engaged as engineer at a plant after this same shop had been doing some work there. The coal consumed was much more than before, and the engineer, of course, was held accountable for the excess. The engine seemed to be working under difficulties and on Sunday, when the steam-chest cover was removed, the cause was apparent. The engine was a 15x30-in., having one of the old-style slide valves. The steam ports were short and direct and there was an exhaust port cored in at each end beside the steam ports which led down to one common exhaust opening under the cylinder.

Thus, there were two slide valves, one for each end of the cylinder, tied together by two heavy tie bolts having right- and left-hand threads to permit the necessary adjustment. Each of these valves had a long lap on the steam side and a short one on the exhaust, but when the repair man reassembled the combination, he put the crank-end valve at the head end, and *vice versa*.

This gave the engine practically no steam lap, while the exhaust lap was excessive, though the engine continued to run it required considerably more steam than before. The back pressure was excessive, and about all the jet condenser could do was to condense the steam without producing a vacuum. When the valves were put in their original position and squared up, and the eccentric advanced, the engine once more ran with its usual ease and quietness, while the fuel was nearly as much lower than before the engine was overhauled as it was higher right after the repair man left the job.

On another occasion a vertical 10x12 engine, directly connected to a centrifugal pump, ran up to speed empty, but with a sharp exhaust. As soon as the load came on, though, the speed was so reduced that the pump ceased to discharge water. On removing the steam-chest cover, it was found that the eccentric had been so set that, with the engine on the center, the valve had the necessary amount of lead but it was closing instead of opening, and real admission did not take place until the piston had advanced to about half stroke. The only adjustment necessary was to set the eccentric properly.

A man may be an excellent machine or bench hand and be entirely ignorant of the fitness of things pertaining to power-plant machinery.

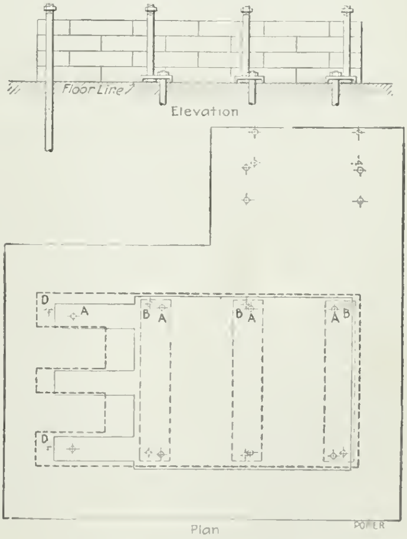
GEORGE H. WALLACE.

Racine, Wis.

* * *

New Engine on Old Foundation

Owing to increasing the load, it was necessary to take out an old gas engine and put in a new one of larger size. The holes in the bedplates were made to a different templet and some changes had to be made in the anchor bolts. The old brick foundation was raised about 17 in. above the floor line. The illustration shows the difference in the templets, the full lines showing the old and the dotted lines the new one; *A* refers to the old bolts, and *B* to the new.



OLD AND NEW FOUNDATIONS

The following method was used to fasten the anchor bolts for the new engine. The old foundation was taken down to the floor line, and the anchor bolts cut off about 3 in. above and threaded. Three pieces of 2x8-in. channel iron were drilled for the old and new bolts.

Concrete was then poured on the old foundation and the channel irons laid in position in it, over the old bolts, with the new bolts in their respective holes. The nuts on the old bolts were then pulled down tightly, the new templet placed over the upper ends of the new bolts, and the new foundation built around them.

The two rear bolts *DD* came in the old exhaust pit, so the rear of the new foundation was built up from the bottom of the exhaust pit with these two bolts anchored as usual. Part of the foundation for the outboard bearing had to be rebuilt, so that two of the bolts could be built in the new part, holes were drilled in the old part for the other two bolts to be grouted in.

The new engine sets as solidly as if the foundation had been built up new all the way from the bottom.

Earl Pagett.

Coffeyville, Kan.

Precaution against Water in Receivers

In operating compound engines, especially those having receivers between the cylinders, great care should be exercised to see that the receiver pressure exceeds that of the atmosphere.

There have been numerous wrecks of low-pressure cylinders (some of them classed as "mysterious") caused by the operators allowing the receiver pressure to get low during periods of light loads and the receiver trap not operating on account of excessive discharge resistance. Considerable water would accumulate in the receiver, and then when the load increased the water was thrown into the low-pressure cylinder.

The remedy is to always keep the receiver pressure higher than that of the atmosphere. This can be done on some engines by shortening the cutoff to the low-pressure cylinder, but if the engine is not equipped with a hand-regulating apparatus, the pressure should be kept up by admitting live steam to the receiver. Some engines are equipped with a combination vacuum and pressure trap which, if kept in good working order, should obviate any danger.

John F. Hurst.

Louisville, Ky.

Commutator Lubrication

A. G. Curren says, in the June 9 issue, that a little vaseline or engine oil on a rag is a good commutator lubricant. That is true in some cases, but there are times when other methods of lubrication must be applied. In fact no two commutators require exactly the same treatment, according to my observation. For instance, in the plant where I am employed there is one generating set that has been in almost daily operation for six years, and during that time the commutators have never been turned down and, to my knowledge, they have never indicated in any manner that they were in need of lubrication. On the other hand, in the same room there is another set working under entirely different conditions. The commutator speed is much higher, and because of the work it performs the commutator becomes quite warm. Vaseline, paraffin, oil and everything else that we thought would prove beneficial, were tried on these commutators, but the results were not satisfactory. What lubricant there was in the brushes when new would soon break out and from then on we were continually applying something to the commutator in an effort to reduce the noise and cutting.

Finally, in the September 26, 1911, issue of Power was published a letter from Mr. Johnson, in which he told of using a piece of flax packing as a commutator lubricant. That idea has saved us much trouble with this particular machine, a booster for charging batteries.

By laying a piece of flax packing on the commutator it is lubricated and the brushes also absorb some of the oil. This we have proved by taking the flax off after several hours' run, after which the machine would then run quietly for a while without requiring further commutator lubrication. After a piece of flax has been used for some time it will, of course, become dry. We have found that kerosene is the best thing with which to moisten it. The use of kerosene is especially valuable on a commutator having a tendency to run to high mica, as the kerosene softens the mica and causes it to wear down as fast as the bars.

H. G. Gibson.

Washington, D. C.

Conserving Niagara

Your editorial on the above subject, in the Aug. 11 issue, prompts me to suggest the following compromise:

Why not utilize the water for power purposes six days and nights a week and let the water flow over the falls on Sundays for the benefit of the tourists?

F. F. Phyvesentz.

East Orange, N. J.

Heat for Beginners

In his article on "Heat, a Lecture for Beginners," in the Aug. 4 issue, Mr. Bromley seems to fall into the error of giving definitions that tend to confuse the practical man.

Quoting from his third paragraph, we have:

> Pressure, of course, has a great deal to do with heat and temperature as related to water. Suppose we had the 1 lb. of water under 400 lb. absolute pressure; that is, the pressure indicated by the gage plus the atmospheric pressure, or 15 lb. The temperature would be 444.8 deg. F. The pound of water would contain 1208 B.t.u. at this temperature.

The fact that 1 lb. of water is placed under 400 lb. pressure would not cause its temperature to be 444.8 deg. F., or any temperature other than that which it had before being placed under pressure.

Furthermore, pressure has nothing to do with heat and temperature as related to water, that is, the same amount of heat is required to raise water 1 deg. F., regardless of the pressure on the water.

Mr. Bromley quite evidently did not intend to convey the idea this part of his article would lead one to conclude. His meaning is clear enough to one who is acquainted with the subject, but to a beginner it is likely to be confusing.

L. H. Morris.

Waco, Texas.

Mr. Morris' criticism may be true as applied to a very few readers. As some readers may misinterpret the article, or at least that part of it to which Mr. Morris refers

I hasten to reply. The introduction stated that the article treated of heat chiefly as related to boiler practice. Any man about the plant knows from observation that water may be under high pressure and still not be hot—for instance, the water in a hydraulic elevator system. Any fireman knows, when he pumps cold water into a boiler preparatory to a hydrostatic test, that when the pressure reaches 100 lb., the water does not have a temperature corresponding to 100 lb. steam pressure. Even the housewife knows that she cannot get hot water from the cold-water faucet, although the city water pressure may be 80 lb. per sq.in. Such facts would indicate that but few have misunderstood the author.

New York City. CHARLES H. BROMLEY.

Direct-Current vs. Three-Phase System

In the Aug. 11 issue, pages 211 and 212, E. M. Marshall compares the three-wire direct-current system with the three-wire, three-phase system. It is evident that he is in error in his computations regarding the copper requirements of the system. If the two-wire system at 110 volts is assumed to require 100 per cent. copper, the three-wire system at 220 volts will require 37½ per cent., all three wires being the same size, while the three-phase system will be 50 per cent. instead of 75 per cent., as Mr. Marshall states. This is evident from the following:

If I equals the current for the two-wire system, the current for the three-wire system will be $I/2$. Hence the copper required for each wire will be in proportion to the square of this, or $\frac{1}{4}$ the copper required for each wire in the two-wire system. With the three wires, the total requirement will be $\frac{3}{8}$ for the three-wire system, or 37½ per cent. Similarly, in the three-phase system, the current will be equal to $\frac{I}{\sqrt{3}}$, so that the copper required in each wire will be equal to $\frac{1}{3}$ of that for each wire in the two-wire system. Hence, the total requirement will be one-half of the two-wire, or 50 per cent., instead of 75 per cent. as stated.

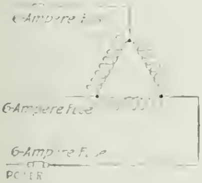


FIG. 1. CUTOUTS AS ARRANGED ON THREE-PHASE CIRCUIT

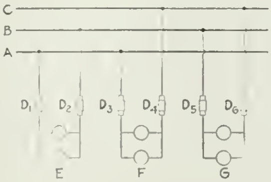


FIG. 2. LIGHTING CIRCUITS FROM THREE-PHASE SYSTEM

Mr. Marshall's conclusions regarding the watts allowed by the Underwriters in the three-phase system, are somewhat erroneous, for it is manifest that Rule 23, Section "d" of the Underwriters' rules requires that not more than 660 watts shall be dependent upon one cutout, and it is manifest that in the three-phase system as shown in Fig. 1 there are three cutouts on which the circuit is dependent and that the opening of any one will not cut current entirely off the circuit. Hence, the Underwriters have allowed currents of 6 amperes in the main branches of circuits wired as in Fig. 1, or a total of 1147 against 1320 watts as allowed in the three-wire, direct-current system, or 86 per cent. as Mr. Marshall stated. However, it is seldom that lighting is done on three-phase circuits according to this method of connection, and the 660-watt rule does not apply to polyphase motors where such a method of connection is ordinarily used. The accepted method of operating lights from a three-phase circuit is as shown in Fig. 2, where A, B and C are the mains and the lighting circuits are at E, F and G, with cutouts at D_1, D_2, D_3, etc. Hence, each of the three circuits E, F and G may carry 660 watts, or a total of 1980 watts, or 50 per cent. more than that allowed in the direct-current, three-phase system advocated by Mr. Marshall.

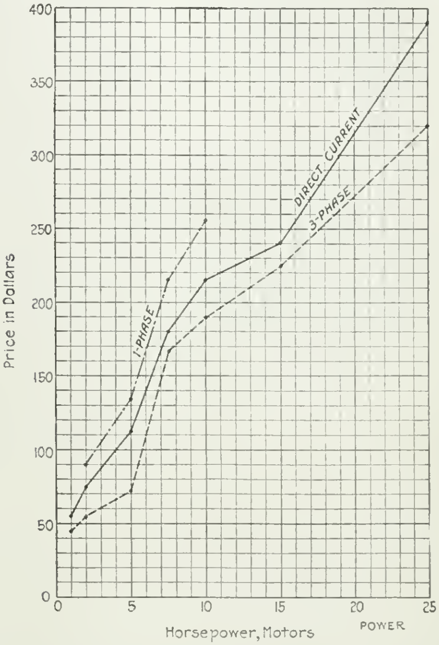


FIG. 3. RELATIVE COSTS OF DIRECT- AND ALTERNATING-CURRENT MOTORS

Moreover, he has failed to mention the real points which usually decide in favor of the alternating-current system, namely, the greater simplicity of the motors and the greater distance to which the alternating current can be transmitted and the possibility of purchasing central-station power for breakdown service.

I wish also to take exception to Fig. 3 in Mr. Marshall's paper showing the relative costs of direct- and alternating-current motors. These are shown by straight lines, which is manifestly inaccurate, as motor prices do not vary according to straight-line curves. I submit herewith curves, Fig. 3, showing relative prices of three-phase direct-current and single-phase motors, as taken from the price forms of a large motor manufacturer. It is to be noted that the prices will depend entirely upon the speed, and it is, of course, impossible to compare prices unless the speeds are approximately the same. This has been done in the present case. All the motors up to and including 5 hp. are at 1700 r.p.m., and those above this size are 1150 r.p.m. It will be noted that the single-phase motors are consistently higher than the direct-current motors, and that the direct-current motors are higher than the three-phase motors. There is no crossing of the prices as indicated by Mr. Marshall, so that three-phase motors are consistently lower in all sizes than either direct or single-phase motors, and direct-current motors are always lower than the single-phase motors.

S. A. Fletcher.

Pittsburgh, Penn.

Joining Broken Lead Pipes under Pressure

It frequently happens that lead pipes conveying water at high pressure are cut or damaged, causing much trouble to make repairs, especially if the water cannot be turned off readily. In this case, cut the pipe at the leak, plug both ends and place a small pile of broken ice and salt around them. In a few minutes the water in the pipe will freeze. Then withdraw the plugs and solder in a new piece of pipe. After thawing the ice, the job will be all right.

Paul Nordstrom.

Hadley, Alaska.

Supporting the Designer

It has been correctly stated, that unless the designer of a power-plant or engineering structure has the full support of his employers to the extent of carrying into effect a logical, consistent and safe design, it were better he resign and save himself much humiliation. A man competent to design power plants should not temporize on a subject involving the success and perhaps the safety of the design. Unless he has the authority to insist upon the execution of a proper design, it would be better he quit, for it is almost certain he will be held responsible for whatever design is adopted.

The faulty breeching connection described by Mr. Park in the Sept. 1 issue (page 316) calls to mind the experiences of a designer who was engaged in the reconstruction of a cement plant. One of the jobs was the remodeling of the boiler plant. Although the designer was fully competent he had no authority and did not receive the support due him, and while his drawings and specifications may have been correct, there was no assurance that the work would be done accordingly. An instance in point was in the construction of some foundations for machinery. Happening to come up while the concrete was being placed, he found that the aggregate, which was being measured by wheelbarrows, was of such amount as to produce a 1 : 3 : 9 mixture where a 1 : 3 : 5 was required, and the broken stone contained 30 per cent. of dirt. Protesting against such construction, the designer was branded as "finnicky" and over particular.

The boiler-house stack and breeching as used in the old plant were found insufficient for the needs, and a new stack and breeching were installed of ample capacity. While the stokers were being installed, and previous to the rebuilding of the setting, the designer left, which fact did not save him from being criticized as being responsible for the poor detail at the uptakes (exactly as described by Mr. Park), although he left instructions how to proceed. It would seem improbable that a designer would lay out the stack and breeching of ample capacity, and then fall down on so obvious a thing as the necessary area around the drums at the uptake.

C. O. Sandstrom.

Kansas City, Mo.

Home-Made Feed-Water Heater

In a New England hotel plant, the feed water was kept at an average of 110 deg. F., and as the plant was equipped with some modern machine tools, including a 16-in. lathe, it was decided to build, without outside help, the feed-water heater shown in Fig. 1.

The body A was a piece of 12-in. cast-iron pipe 3 ft. 6 in. long. The tube sheets B and B', also cast iron, were made a driving fit against the shoulders, and further secured by the setscrews T.

The holes in the tube sheet B were countersunk, and when the tubes were in place, the cavities were filled with solder, Fig. 3, so that the tubes were firmly secured at one end. In the other tube sheet B', the tubes were made a neat fit, and when the heater warmed up, the coefficient of expansion of brass being greater than that of iron, a steam-tight joint would be formed, and at this same time, allow for the tube expansion and contraction.

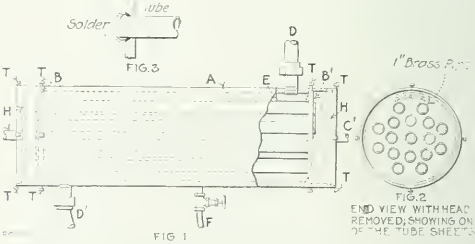


FIG. 3

FIG 1

FIG. 2
END VIEW WITH HEAD REMOVED; SHOWING ONE OF THE TUBE SHEETS

Construction of Heater

The two cast-iron heads HH were held in place by setscrews as shown, and a rubber gasket between the heads and the shoulders insured a tight joint. Water passed in through C and out through C'. The steam inlet was at D, exhausting through D'. A baffle-plate E, secured to the tube sheet B', protected the upper tubes from the impinging steam.

It will be noticed that the steam inlet was piped in close to the tube sheet B', thus warming up the tubes at that end before the water was turned on and forming the steam-tight joint.

The drain F leading to the feed tank was kept open while the heater was in operation. The feed water entered the heater at about 110 deg. and left at an average of 200 deg. F.

These figures will give an idea of how much coal was saved:

Average consumption of feed water per hr. = 34,500 lb.
B.t.u. saved per hr. = (200 — 100) × 34,500 = 3,105,000.
Equivalent amount of coal saved per hr. = 3,105,000 ÷ 13,500 = 230 lb.
Coal saved per 24 hours = 2.76 tons.

Samuel J. Robinson.

Port au Prince, Haiti.

Indiana Boiler Law

The editorial under the above caption in the issue of Aug. 28, mentions some of the defects in the Indiana boiler law. There is, however, another section not mentioned which, I believe, makes a dangerous condition possible. It is as follows: "Sec. 17. On all steam lines there must be a cutoff valve placed in the steam pipe not farther than 18 in. from the boiler shell."

"On all boilers installed on and after July 1, 1913, where two or more boilers are connected to the same steam line or main, the branch pipe to each boiler shall be provided with two stop valves, one to be placed near the steam main and the other not farther than 18 in. from the shell of the boiler. In water-tube and all boilers carrying 100 lb. steam pressure or over, an automatic shutoff valve must be placed between the boiler and stop valve."

Fig. 1 shows a connection that conforms to the first paragraph; Fig. 2, the construction required by the second paragraph with a valve within 18 in. of the boiler and and one near the header. The law does not require a drain valve in either case. If the boiler is to carry over 100 lb. pressure there must be an automatic shutoff valve between the boiler and the stop valve. This would either require three valves, or the substitution of the automatic valve for one of the stop valves, which is practicable. Fig. 3 shows the same kind of connection where the head room is limited, and the branch must be nearly horizontal.

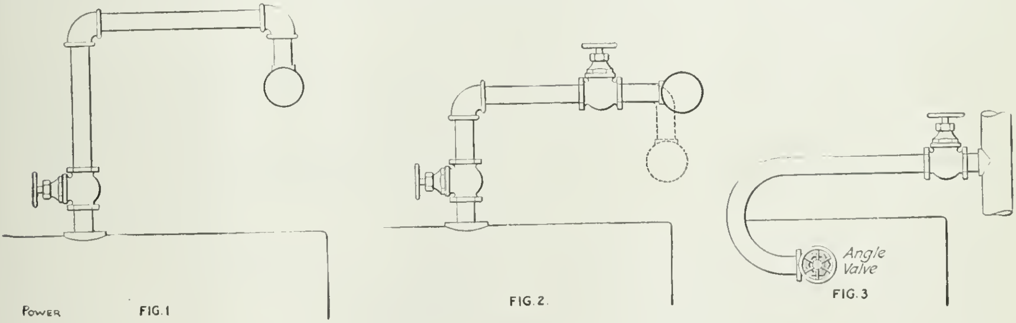


FIG. 1 FIG. 2. FIG. 3

Three Types of Connections Permitted by the Indiana Law

If a drain pipe is connected above the valve and used properly every time the boiler is put into service, there is but little chance for damage from water-hammer. Safety laws are made to eliminate dangerous conditions so far as possible, but if they do not prevent dangerous construction or operation, what are they good for? Since the law in question does not require a drain, a contractor would be within the law in omitting it.

For several years, I had charge of a plant with the boilers connected as shown in Fig. 1, with a drain valve just above the stop valve. On one or two occasions the drain was not opened, and from the noise of the water-hammer, I thought that a boiler had exploded.

In another case, a horizontal branch had a valve on each end, but no drain; the stop valve on the boiler was burst by water in the line. Water-hammer is dangerous. Every means should be taken to prevent it and the piping so arranged that no pockets of water can be formed. This would do away with the necessity for hand drains, traps or other arrangements which depend on the operator, and the cost of construction need be no greater. The piping as shown might be operated for years without trouble but, some time, one might lose his life from improper operation of the valves. The law should be so amended that it will eliminate the possibility of water-hammer at this point. In boiler plants already installed, traps and drains may be permissible, but all new work should be self-draining. This cannot be done under the present Indiana law.

J. C. Hawkins.

Hyattsville, Md.

*

Vacuum Ash-Handling System

As quite a number of plants in this country use the vacuum ash-handling system, the following points obtained from several years' experience may be of interest:

One system at first had no dust collector; it was put in later, only to be taken out as the fine ash mixed with moisture clogged up all the openings in the separator, causing its collapse. The manganese wearing backs of the elbows last about three months by turning them end for end after six weeks' wear. The extra-heavy steel ash pipe, fitted with standard flanges, flush and faced at the ends, would last six months on a horizontal run if it were turned one-half way around after three months' wear, so as to expose a new surface to the action of the ash.

Cleaning red ash out of the combustion chamber is difficult, and can be done only by mixing with the hot furnace ash.

After two or three years' use in handling 20 tons of ash daily, the exhauster blower will begin to depreciate in efficiency, due to the wearing action of the ash dust. The life of the blower can be prolonged a year or two by using a dope of fireclay, old pulverized magnesia pipe covering and a cheap axle or cup grease. This mixture is admitted to the suction side of the machine, as closely as possible while it is in operation, so that it will fill the unduly worn clearance spaces.

At times the fine ash dust will so choke the machine as to render its operation impossible. Then a liberal use of kerosene in the suction will remedy matters, after which it will be necessary to use more of the mixture.

I have found it advisable to remove the suction nozzle from the machine once a year because it fills with a de posit that interferes with the capacity unless removed. On account of the comparatively low vacuum carried on the system it is hard at times to locate such troubles by gage testing.

A few years ago, after the first system of piping showed signs of wear, it was concreted, using the pipe as the internal form. This pipe lasted about a year, with a lot of patching, but it had to be replaced. The work entailed in removing the concrete offset any advantage that could be gained by its use.

Louisville, Ky. JOHN F. HURST.

*

Trouble with an Air Lift

We have a 6-in. well 326 ft. deep. The water comes within 30 ft. of the top and we use an air lift for raising it. The end of the 1-in. air line was plugged, and in about 3 ft. of it there were drilled $\frac{1}{16}$-in. holes. This pipe extended 136 ft. into the well.

The pumps were run only long enough to fill the tanks, but one evening we failed to get water. Usually, 60 lb. of air was sufficient, but 80 lb. failed to raise it, and this was the limit of air pressure we could get.

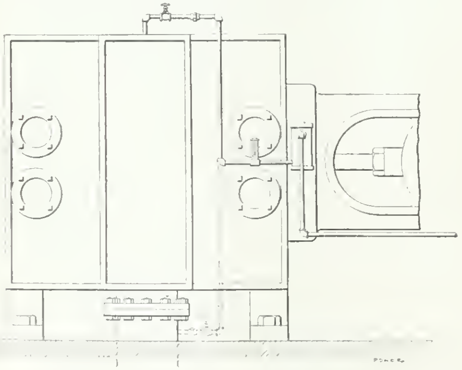
We pulled the air line out and found the perforated section entirely covered with lime. All new pipe was then put in and about 36 ft. added. The holes in the perforated section were made $\frac{1}{8}$ instead of $\frac{1}{16}$ in. I would like to know if this is a common occurrence, as it is the first time it has happened here. The well had not been opened in 14 years before this.

Julietta, Ind. ARTHUR V. LACY.

*

Faulty Engine Lubrication

A new high-speed, four-valve engine was recently installed in a Washington plant. The engine was given a factory test before shipping, the cylinder lubricator connections were left intact when the engine was shipped and the oil pipe from the lubricator entered the valve chest on top, as shown by the full lines in the sketch.



ORIGINAL AND CHANGED LUBRICATOR PIPING

The engine was assembled and started up, but trouble was had from the first by the seeming inability of the valves to get enough oil. After a few weeks' run they were found so badly cut in places that they were returned to the factory, their appearance warranting the belief that plenty of oil was getting to them but that it was not being properly distributed.

It was then decided to introduce the oil into the steam pipe at the point shown in the sketch by the dotted lines. This was done on the theory that the oil would have more opportunity to mix with the steam before reaching the valves, thus obtaining better distribution. To aid the mixing of the oil with the steam the pipe extending into the steam pipe was perforated with small holes and plugged at the end.

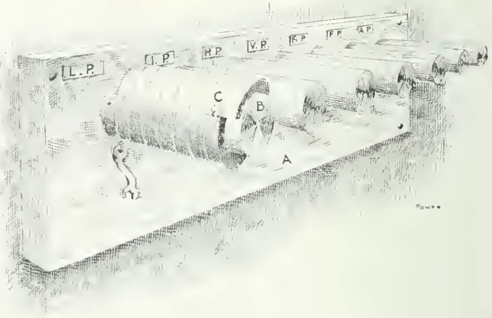
The results of the change, after several months' trial, are satisfactory, with no more trouble in securing a distribution of oil over the interior surfaces requiring lubrication.

Washington, D. C. H. G. GIBSON.

*

Rack for Packing

Engineers and oilers sometimes have trouble when new packing is needed at once on the piston rods of pumps or engines. Some piston packing comes in spiral form and is usually kept loose in a box or in a bench drawer, all mixed together. When a few rings are required in a hurry the proper size cannot be readily found; it is generally at the bottom of the tangle.



CONVENIENT RACK FOR SPIRAL PACKING

A rack board, made as shown in the illustration, was found convenient for the purpose. Holes were bored in a 2x4-ft. board *A*, and wooden pins driven into them. The pins were turned to compare with the diameter of the different engines and pump piston rods. Above each stud a label was pasted to indicate the nature of packing.

The packing was wound around the pins, as shown, with the inner end fastened to the stud. When a ring was required it was only necessary to twist the packing tight on the pin and cut as shown by the dotted line *C*, with an allowance for taking up with the glands.

To render this easier and have a standard length in packing rings, the wooden studs were turned a trifle smaller in diameter than the rod in question to allow for the expansion of the packing. This difference varies for different packing and sizes, and can be tried out on the rod itself.

Under each packing pin the wrench is hung for the gland nuts of that particular size packing. The pins can be arranged as shown, with the larger diameter packing first, and so on down to the smallest size.

New York City. J. A. LUCAS.

Inquiries of General Interest

Overload of a Boiler—What is meant by operating a boiler with 25 per cent. overload?

W. S. H.

That the evaporation is 25 per cent. in excess of the rated capacity of the boiler.

Calorific Value of Fuel Oil—What is the calorific value of fuel oil?

C. F.

American fuel oil as fired has a calorific value of about 16,000 to 19,500 B.t.u. per lb., varying with the locality and the percentage of water contained.

Feeding and Firing While Blowing Down—What damage would result to a boiler by continuing the firing or running the feed pump while blowing down?

J. B.

There should be no damage resulting to a boiler from continuing the feeding and firing while blowing down.

Shape of Iron Tank Bottoms—Why are the bottoms of iron tanks made conical or hemispherical?

S. W.

For greater strength of the bottom when the tank is supported around the sides, this method of supporting iron tanks being desirable as it admits of ready access to the joints for calking.

Running Smoothly Without Compression—Is it possible for a simple slide valve engine that is making 190 turns per min. to run smoothly without compression of the exhaust?

D. W.

It is possible by obtaining cushioning effect with lead and by having the bearings in good condition and the connecting rod brasses skillfully adjusted.

Water Rate of Turbo-Generator Set—How is the water rate per kilowatt-hour of a turbo-generator set determined?

E. C. S.

The water rate is usually found by determining the weight of the condensate of the steam used during a stated period and dividing the number of pounds per hour by the actual kilowatt output per hour during the same period

Crushing Strength of Plate—In formulas for strength of riveted joints, what is meant by "crushing strength of plate?"

E. W. S.

The term "crushing strength of plate" refers to the strength of the material to resist crushing from the compressive force which results from transmitting a shearing stress to the rivets.

Designating the Degrees of Elbows—As 45 deg. is only one-half of 90 deg., why is a 45-deg. elbow so called when the actual angle of the elbow is 90 + 45, or 135 deg.?

G. K.

Elbows are designated according to the number of degrees which they deflect a pipe line from a straight line, and not by the number of degrees contained by the angle of their axes. There are thus 30-, 45-, 60- and 90-deg. elbows. A coupling would be 0, and a return bend is often designated a 180-deg. elbow.

Preserving Proper Length of Connecting Rod—In taking up the wear of connecting rod brasses, what must be done to keep the rod the proper length?

F. K.

In taking up the wear, the rod becomes longer or shorter according to the method employed for tightening the brasses and to compensate for the reduction of the thickness of the brasses from wear, and preserve a length of rod which will give proper clearance between the piston and ends of the cylinder, shims consisting of thin sheets of metal are to be placed behind the brasses.

Effect of Advancing Eccentric—What effect has advancing the eccentric on the power that can be developed by a single eccentric Corliss engine?

V K

With normal adjustment of the valve gear, it has the effect of reducing the power which the engine is capable of developing, as advancing the eccentric shortens the maximum cutoff at which the valve-gear can operate, hastens the release by earlier opening of the exhaust and increases compression by earlier closure of the exhaust, all of which reduce the maximum m.e.p. capable of being developed with a given initial pressure.

Placing Engine on Center by Leveling vs. Tramming—Which is the more accurate method of placing a horizontal engine on a dead center, by applying a machinist's level to one end of the connecting rod, or by tramming?

J. F. F.

The method of tramming is more accurate, because accuracy in determination of the dead center by use of a level depends on truthfulness of level of the center of the shaft with the crosshead pin, parallelism of connecting rod center line with the part of the connecting rod which is used to support the base of the level, the accuracy and sentitiveness of the level, and personal error in observing the indications of the level bubble, any of which is more likely to be a source of greater error than the accumulation of errors from ordinary care in determining the dead center position of the crankpin by tramming.

Height of Injector or Siphon Condenser—Why must an injector or siphon condenser be 34 ft. above the level of the tail water?

L. A. H.

The height of the column of water between the condenser and hotwell, or tail water, must be as great or greater than that which atmospheric pressure will support with a given vacuum, so that the constant supply of condensing water will produce a continuous downward flow. With a perfect vacuum, atmospheric pressure will support a column of "solid" water nearly 34 ft. high and higher if the water is rarified by the presence of air. To insure a continuous downward discharge of the condensing water and to prevent it from being carried over to the exhaust with a perfect vacuum, the condenser must be placed at least 34 ft. above the level of the hotwell or tail water.

Size of Steam Pipe—Neglecting drop in pressure due to friction or condensation and allowing a velocity of 5000 ft. per minute, what diameter of pipe would be required to supply 6500 lb. of steam per hour at a gage pressure of 70 lb.?

M. S.

The volume of a pound of steam at 70-lb. gage pressure or

$$70 + 14.7 = 84.7 \text{ lb. absolute,}$$

would be between the volume of a pound of steam at 84 lb. per sq.in. absolute and 85 lb. absolute. According to Marks and Davis steam tables, the volume of a pound of steam at 84 lb. absolute is 5.22 cu.ft., and at 85 lb. absolute the volume is 5.16 cu.ft. Interpolating between these values, the volume of a pound (wt.) of steam at 84.7 lb. absolute is found to be

$$5.22 - [(5.22 - 5.16) \times (84.7 - 84)]$$

or

$$5.22 - (0.06 \times 0.7) = 5.178 \text{ cu.ft.}$$

To supply 6500 lb. per hour would require a flow at the rate of

$$\frac{6500}{60} = 108.33 \text{ lb. per min.}$$

or

$$108.33 \times 5.178 \text{ cu.ft. per min.,}$$

and the cross-sectional area of a pipe required for that flow with a velocity of 5000 ft. per min. would be

$$\frac{108.33 \times 5.178}{5000} = 0.112 \text{ sq.ft or } 16.13 \text{ sq.in}$$

Hence the size of the pipe should be

$$\sqrt{\frac{16.13}{0.7854}} = 4.53 \text{ in. diameter,}$$

or practically a 4½-in steam pipe would be required.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXIX

LAST LESSON'S ANSWERS

131. In equation (78) it was shown that the acceleration with which a point is drawn toward the center of a rotating body is $\frac{V^2}{R}$, where V is the linear velocity of the point, located R feet from the center of rotation. In this case the linear velocity of a point on the rim of the wheel is $2 \times 3.1416 \times 5 \times 100 = 3141.6$ *ft. per min.* or 52.36 *ft. per sec.*, since the radius of the rim is 5 ft. Therefore, the acceleration is

$$a = \frac{(52.36)^2}{5} = 548.3 \textit{ ft. per sec. per sec.}$$

132. The weight of the rim may be found by the method explained in problem (128), thus

$$W = \frac{8 \times 10 \times 351.9}{1728} \times 450 = 7330 \textit{ lb.}$$

The weight per inch length of rim is equal to the total weight of the rim divided by the circumference of a circle whose diameter is the mean diameter of the rim. Let w = the weight in pounds per inch length of rim, then $w = \left(\frac{7330}{351.9}\right) = 20.8$ *lb.*, and the centrifugal force per inch length of rim is $\frac{wV^2}{gR}$, where V is the linear velocity of the point, located R feet from the center of rotation, and equals

$$3.1416 \times (9\tfrac{1}{3} \textit{ ft.}) \times \tfrac{100}{60} = 48.87 \textit{ ft. per sec.}$$

Therefore the centrifugal force per inch of rim is

$$\frac{20.8 \times 48.87 \times 48.87}{32.16 \times (4\tfrac{2}{3} \textit{ ft.})} = 331 \textit{ lb.}$$

133. The pressure on the bearings is equal to the centrifugal force of the unbalanced weight of 5 lb. From equation (79) the centrifugal force is $\frac{WV^2}{gR}$, where W = 5 lb.; V = the velocity of the weight in feet per second $= \frac{1500}{60} \times 3.1416 \times 3 = 235.6$ *ft.* and R = the radius of gyration = 1.5 ft. Therefore, the centrifugal force is

$$C = \frac{5 \times 235.6 \times 235.6}{32.16 \times 1.5} = 5753 \textit{ lb.}$$

which gives the excess pressure on the bearings. This high speed was assumed to show the great strain that comes on the bearings supporting a shaft that holds an unbalanced wheel of any sort.

134. Assume only the weight of the balls A and B. In Lesson IV, Fig. 15, it was shown that there are three forces acting on the ball A, and, as these forces are in equilibrium, they may be represented by the sides of the triangle $EFGE$, Fig. 82, where the side EF is the weight of the ball; the side GF the centrifugal force C; and the side GE gives the tension in the supporting link. This force triangle has its sides respectively parallel to the triangle $OMAO$, Fig. 81, and therefore the two triangles are similar. Hence

$$\left(\frac{\textit{centrifugal force } C}{\textit{weight } W}\right) = \left(\frac{\textit{side } AM}{\textit{side } OM}\right) = \frac{R}{H}$$

and as $C = \frac{WV^2}{gR}$, it follows that

$$\frac{\left(\frac{WV^2}{gR}\right)}{W} = \frac{R}{H}, \text{ or } \frac{V^2}{g} = \frac{R^2}{H}$$

This equation shows that, *neglecting the friction*, the action of the flyball governor is independent of the weight of the ball. The velocity $V = 2 \times 3.1416 \times R \times N$ *ft. per sec.*, where N = the revolutions per second, hence,

$$\frac{(2 \times 3.1416 \times R \times N)^2}{32.16} = \frac{R^2}{H} \text{ or, } N^2 = \frac{0.815}{H}$$

But $H = OA \cos 30$ *deg.* = 1.5 *ft.* × 0.866 = 1.299 *ft.* Therefore,

$$N^2 = \frac{0.815}{1.299} = 0.63 \text{ or } N = 0.79 \textit{ rev. per sec.} = 47.4 \textit{ r.p.m.}$$

135. If the angle OAM is 20 deg., then $H = 1.5 \times \cos 20$ *deg.* $= 1.5 \times 0.94 = 1.41$ *ft.* and

$$N^2 = \frac{0.815}{H} = \frac{0.815}{1.41} = 0.58, \text{ or } N = 0.76 \textit{ rev. per sec.}$$
$$= 45.6 \textit{ r.p.m.}$$

The reduction in speed = (47.4 — 45.6) = 1.8 r.p.m.

MECHANICS OF BELTING

One of the common questions raised in the power plant and in the shop is: What size belt shall be used to transmit a given horsepower? This may be answered by the application of the principles of mechanics outlined in the previous lesson. Thus the force of friction between two bodies is dependent upon the normal pressure and the coefficient of friction. In the case of a belt this force of friction tends to change the tension in the two sides of the belt.

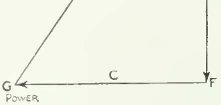


FIG. 82

In Fig. 83, if a belt be stretched over the two pulleys A and B (assumed idle) and spring balances be placed on the top and bottom sides of the belt it will be found that these balances will register approximately the same tension I. Now if the pulley A be put in motion, it is a matter of experience that the lower or driving side of the belt will tend to lengthen and as a result the upper side will become slack. Stated in other words, the tension in the driving side increases and the tension in the slack side decreases. This difference in the tensions is due to the force of friction acting between the belt and the face of the pulley. In Fig. 84 let the pulley A be the driver and the pulley B the follower. Let T_1 be the tension in the tight or driving side of the belt and T_2 be the tension in the slack side. Let a = the arc of contact between the belt and the face of the smaller pulley B, expressed in radians; and let f = the coefficient of friction of the belt. By the aid of higher mathematics, it may be shown that the relation between the tensions of the tight and slack sides of the belt is expressed by the equation

$$\log_e\left(\frac{T_1}{T_2}\right) = f \times a \qquad (81)$$

where e is the Naperian base of logarithms. This equation may be expressed in simpler form by changing the Naperian to the common logarithm from the fact that the common log. = 0.434 × the Naperian log, hence,

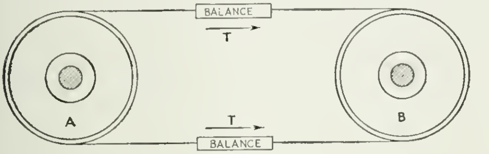


FIG. 83

$$\log_{10}\left(\frac{T_1}{T_2}\right) = 0.434 f \times a \qquad (82)$$

which may still further be simplified by inserting in place of a radians its equivalent value in degrees. Let N = the ratio of the arc of contact to the circumference of the smaller pulley. If there are a radians in the arc of contact, then $N = \frac{a}{2\pi}$ or $a = 2\pi N$ (since there are 2π radians in the circumference of a circle). This ratio N might also be found by dividing the arc of contact in degrees by 360 (the number of degrees in the circumference of a circle). Now substituting the value of $a = 2\pi N$ in equation (82), there results:

$$\log_{10}\left(\frac{T_1}{T_2}\right) = 0.434 \times f \times 2\pi \times N = 2.73\, fN \qquad (83)$$

If the distance between the pulleys is large and the diameters are nearly the same, then N will equal approximately 0.5. Under average conditions, the coefficient of friction f will equal about 0.3 so that

$$\log_{10}\frac{T_1}{T_2} = 2.73 \times 0.3 \times 0.5 = 0.409$$

and from a table, the value of $\log\left(\frac{T_1}{T_2}\right)$ is found to be approximately 2.5. The effective driving effort P, exerted by the belt will be the difference between the tensions in the tight and slack sides or,

$$P = T_1 - T_2 \qquad (84)$$

If the velocity of the belt is V feet per minute, then the work done in foot-pounds per minute will equal $P \times V$ (force times distance) and the horsepower transmitted by the belt will be given by the equation,

$$hp. = \frac{P \times V}{33{,}000} \qquad (85)$$

Example—A single leather belt $\frac{5}{32}$ in. thick is capable of standing about 400 lb. per sq.in., so that for every inch of width a working tension of $400 \times \frac{5}{32}$, or 62 lb., may be placed on the belt. Derive a simple rule for the horsepower transmitted by a single belt.

Solution—Assuming an arc of contact of 180 deg. and a coefficient of friction = 0.3, the relation between T_1 and T_2 will be as previously found, namely, $\frac{T_1}{T_2} = 2.5$, or $T_2 = 0.4\,T_1$. The effective driving effort

$$P = (T_1 - T_2) = (T_1 - 0.4\,T_1) = 0.6\,T_1$$

Now the allowable pull is 62 lb. per in. of width so that the effective pull is

$P = 0.6\,T_1 = 0.6 \times 62 = 37.2$ *lb. per in. width of belt.* One horsepower = 33,000 ft.-lb. The work done by the belt equals $P\,V$ ft.-lb. per minute so that the velocity required of a single belt 1 in. wide to deliver 1 horsepower must equal $\frac{33{,}000}{37.2}$ or 885 ft. per min.

The above problem is the basis for the commonly accepted rule that *a single leather belt traveling at 900 ft. per min. will transmit one horsepower for every inch of its width.* Theoretically, a double belt will transmit twice the horsepower of a single belt but actually it will only transmit about 1.4 times as much.

STUDY QUESTIONS

136. The distance between the centers of two pulleys, 18 in. and 30 in. in diameter, is 10 ft. Find the arc of contact on the smaller pulley, assuming an open belt.

137. If the coefficient of friction is 0.3, find the relation between T_1 and T_2 in the above problem.

138. If the smaller pulley makes 300 r.p.m., find the horsepower transmitted by a belt $\frac{5}{32}$ in. thick and 12 in. wide, asuming that the belt is good for 60 lb. per in. of width.

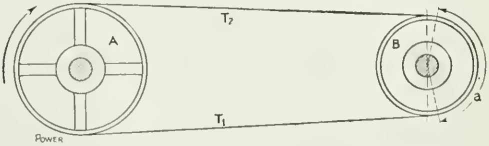


FIG. 84

139. A belt is traveling at the rate of 2700 ft. per min. Find by the approximate rule the horsepower transmitted by a single belt 15 in. wide.

140. If a double belt were used, what would be the horsepower transmitted?

⁂

A High Boiler Pressure is to be carried on the battleship "Nevada," just launched—295-lb. gage. Oil-fired Yarrow-type boilers will be used.

⁂

Electric Welding—It was reported at a recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers that in repairing cracks in the side sheets of locomotive fireboxes a substantial saving had been effected by the use of an electric welding apparatus. The cost of welding forty cracks of various lengths was only \$6.65, against an estimated cost of \$1400 for replacing the injured sheets.

⁂

An Amalgam is an alloy of metals, one of which is always mercury. Mercury has the power of dissolving almost all other metals and mixing with them. It is much used in separating gold and silver from other ores. Among the numerous amalgams are: Tin amalgam, for silvering mirrors; gold and silver amalgam, for gilding and silvering; cadmium and copper amalgam, used in dentistry, etc. Some are solid while others are liquid. Mercury can be distilled off from most amalgams by heating them in retorts. It is in this way that gold and silver are recovered from their amalgams.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

A pointer! "Don't point at anything electrical," admonishes the Rochester Ry. & Light Co. And there is a large illustration posted for its employees, showing how to point—away from the apparatus. Another pointer: Don't point at all!

⁂

"Made in America!" Can we make this slogan heard all over the world? Looks as though we could if our manufacturers and exporters properly steer the industrial boat instead of rocking it.

⁂

Three-thousand pound angels are being raised at the Exposition grounds—by a locomotive derrick having its boom extended by a 66-ft. spar to a radius of 106 ft. Even angels, bronze ones anyhow, are glad to have old man Steam give 'em a lift.

⁂

The Pennsylvania R.R. has 170 ranking officers, 163 of whom started in sweeping out, carrying water—doing chores. And 142 of these men have been over 20 years with the road. It pays to stick when the sticking is good. But pick a good place to stay stuck.

⁂

HORAN—There's an outrageous lot of liars these days, Dinny.

DORAN—True fer you, Hughey, an' 'tis passin' strange, bein' so widespread and apparently easy, that the art of lyin' is so far from perfection.

⁂

We were beginning to wonder if our old friend Tim Healy had been eclipsed by his duties as coroner, when up he bobs as a open-market committeeman and trying to teach the New York school children how to buy food and lessen the cost of living.

⁂

THAT PROUD MOMENT

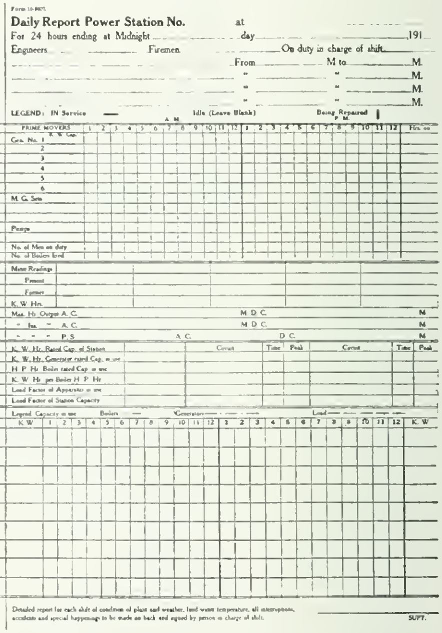
Looking backward, and downward a couple of lines, remember the day your Lizzie came over to the plant, and you showed her about? And you lugged around the oil can (as an emblem of authority, for you were only a kid then), and you pointed out the equipment, and told Lizzie what each part did—or what you thought it did, and 'twas all the same to Lizzie. Gee! but have you ever felt as big since? You bet you haven't, nor won't!

Power-Plant Report Sheets

By W. G. Webster

The report blanks, Figs. 1 and 2, are used by a large power system having several plants. They can be adopted by any power station producing electrical energy. Fig. 3 is a form of report sheet for producer-gas power plants which, by making a few changes, can also be used in any size plant.

The daily report sheet for the power station is applicable to almost any station generating electricity, either alternating, direct current or both. Space is provided for a record of the men on shift and when the shift changes, for recording the generating apparatus in service, and for the hour the units were in and out, thus making it easy to learn the period a machine was in service, and why it was taken off. When motor-generator sets or rotary converters are used, a record is had of the length of the run and the time on and off, regardless of the number of times they are started or stopped. Likewise, a record of the pumps or other apparatus is kept. The line representing the number of men on duty at any particular time is especially valuable. The record of boilers under steam or off or being repaired is also kept. The meter readings are of the output in kilowatt-hours for each unit during the twenty-four hours.



Form 10-9877.

Daily Report Power Station No. at

For 24 hours ending at Midnight day 191

Engineers Firemen On duty in charge of shift

From M to M.

" " M.

" " M.

" " M.

LEGEND: IN Service ——— Idle (Leave Blank) Being Repaired |

PRIME MOVERS K. W. Cap.	A. M. 1	2	3	4	5	6	7	8	9	10	11	12	P. M. 1	2	3	4	5	6	7	8	9	10	11	12	Hrs. on
Gen. No. 1																									
2																									
3																									
4																									
5																									
6																									
M. G. Sets																									
Pumps																									
No. of Men on duty																									
No. of Boilers fired																									

Meter Readings

Present

Former

K. W. Hrs.

Max. Hr. Output A. C. M. D. C. M.

" Ins. " A. C. M. D. C. M.

" " " P. S. A. C. D. C. M.

		Circuit	Time	Peak	Circuit	Time	Peak
K. W. Hr. Rated Cap. of Station							
K. W. Hr. Generator rated Cap. in use							
H. P. Hr. Boiler rated Cap. in use							
K. W. Hr. per Boiler H. P. Hr.							
Load Factor of Apparatus in use							
Load Factor of Station Capacity							

Legend Capacity in use Boilers ——— Generators —·—·— Load ———

K. W.	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	K. W.

Detailed report for each shift of condition of plant and weather, feed water temperature, all interruptions, accidents and special happenings to be made on back and signed by person in charge of shift.

SUPT.

Fig. 1. Daily Report Sheet

Maximum-hour output records are valuable, as they show the maximum-hour demand on the plant in kilowatts, and at what hours it occurred for both alternating-current and direct-current loads.

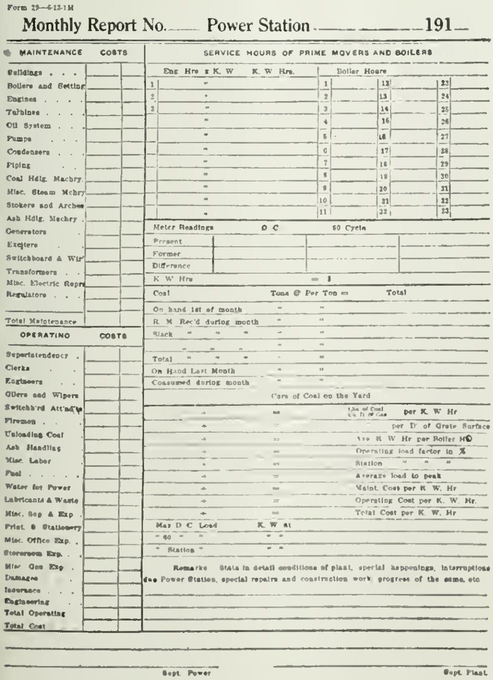
The kilowatt-hour rated capacity remains constant unless changes are made in adding to or taking out generating equipment. The kilowatt-hour generator capacity in use is found by the sum of the rated capacities of the units times the hours each was in service.

The rated horsepower-hour boiler capacity is obtained by the same method, and shows the relation between the kilowatt-hour generator capacity and the boiler-horsepower capacity. The kilowatt-hour per boiler-horsepower shows this relation in percentage.

The percentage of load factor of the apparatus is found by dividing the total kilowatt-hour output by the kilowatt-hours of the generator capacity in use. The load factor shows the load percentage of the station capacity; the remainder of the report is used to indicate that of the boiler-horsepower at any time during the day. The generator capacity is also recorded; the kilowatt-hour output is shown graphically. On the back of the report sheet are recorded the conditions, interruptions, etc.

The sheet may be extended at the top and holes punched for filing. An attractive sheet is made by using black for all the numerals, wording and vertical lines, and blue for the horizontal lines.

Space could well be provided, as in the Fig. 1 report sheet, for the total kilowatt-hours generated and for outdoor and indoor and feed-water temperature, vacuum or any other hourly reading.



Form 29—6-12-1M

Monthly Report No.____ Power Station ____________191_

MAINTENANCE	COSTS	
Buildings . . .		
Boilers and Setting		
Engines		
Turbines		
Oil System . . .		
Pumps . . .		
Condensers . . .		
Piping . .		
Coal Hdlg. Machry.		
Misc. Steam Mchry		
Stokers and Arches		
Ash Hdlg. Machry .		
Generators .		
Exciters .		
Switchboard & Wir		
Transformers . .		
Misc. Electric Repr		
Regulators . . .		
Total Maintenance		

OPERATING	COSTS	
Superintendency .		
Clerks . .		
Engineers . .		
Oilers and Wipers		
Switchb'rd Att'nd'ts		
Firemen . . .		
Unloading Coal .		
Ash Handling .		
Misc. Labor .		
Fuel		
Water for Power		
Lubricants & Waste		
Misc. Sup. & Exp. .		
Print. & Stationery		
Misc. Office Exp. .		
Storeroom Exp. .		
Misc. Gen. Exp. .		
Damages .		
Insurance . . .		
Engineering . .		
Total Operating		
Total Cost		

SERVICE HOURS OF PRIME MOVERS AND BOILERS

	Eng Hrs x K. W	K. W Hrs.	Boiler Hours					
1	=		1		12		23	
2	=		2		13		24	
2	=		3		14		25	
	=		4		16		26	
	=		5		16		27	
	=		6		17		28	
	=		7		18		29	
	=		8		19		30	
	=		9		20		31	
	=		10		21		32	
	=		11		22		33	

Meter Readings	D C	60 Cycle	
Present			
Former			
Difference			

K W Hrs = $

Coal Tons @ Per Ton = Total
On hand 1st of month " "
R. M. Rec'd during month " "
Slack " " " " "
" " " " "
Total " " " " "
On Hand Last Month " "
Consumed during month " "

Cars of Coal on the Yard

÷ = Lbs. of Coal / Cu. ft. of Gas per K. W. Hr
÷ = per D' of Grate Surface
÷ = Ave. K. W. Hr. per Boiler HP
÷ = Operating load factor in %
÷ = Station " " "
÷ = Average load to peak
÷ = Maint. Cost per K. W. Hr
÷ = Operating Cost per K. W. Hr.
÷ = Total Cost per K. W. Hr

Max D C Load K. W. at
" 60 " " " "
" Station " " "

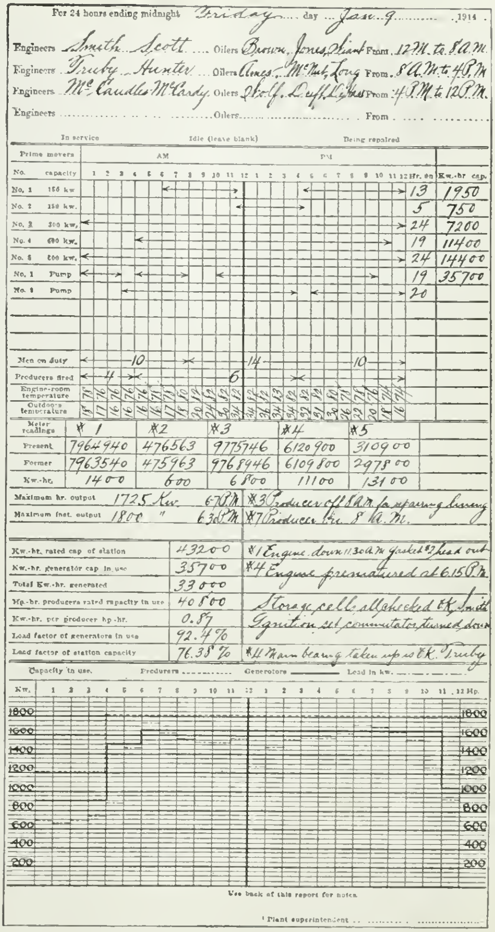
Remarks: State in detail conditions of plant, special happenings, interruptions due Power Station, special repairs and construction work, progress of the same, etc.

Supt. Power

Supt. Plant

Fig. 2. Monthly Report Sheet

The monthly report, Fig. 2, made up from the daily reports, is self-explanatory, and covers the main items of interest. When one keeps a record of plant operation, there is something to show when the central-station man comes around and tries to tell what he will do in the matter of cheap power.



For 24 hours ending midnight Friday day Jan. 9 1914

Engineers Smith Scott Oilers Brown, Jones, Stuart From 12 M. to 8 A.M.
Engineers Truby Hunter Oilers Ames, McNut, Long From 8 A.M. to 4 P.M.
Engineers McCandles McCardy Oilers Wolf, Duff, Lykes From 4 P.M. to 12 P.M.
Engineers .... Oilers .... From ....

In service Idle (leave blank) Being repaired

Prime movers No.	capacity	Hr. on	Kw.-hr cap.
No. 1	150 kw.	13	1950
No. 2	150 kw.	5	750
No. 3	300 kw.	24	7200
No. 4	600 kw.	19	11400
No. 5	600 kw.	24	14400
No. 1	Pump	19	35700
No. 2	Pump	20	

Men on duty 10 14 10
Producers fired 4 6

Hour	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Engine-room temperature	78	76	76	76	76	78	78	80	82	82	82	82	82	82	83	82	82	82	80	78	78	76	74	74
Outdoors temperature	18	17	16	16	16	16	17	18	20	24	30	34	34	36	34	34	32	31	30	26	22	20	18	16

Meter readings	#1	#2	#3	#4	#5
Present	7964940	476563	9775746	6120900	310900
Former	7963540	475963	9768946	6109800	297800
Kw.-hr.	1400	600	6800	11100	13100

Maximum hr. output 1725 Kw. 6 P.M. #3 Producer off 8 A.M. for repairing lining
Maximum inst. output 1800 " 6.30 P.M. #7 Producer fire 8 A.M.

Kw.-hr. rated cap. of station	43200	#1 Engine down 11.30 A.M. gasket #2 head out
Kw.-hr. generator cap. in use	35700	#4 Engine premature at 6.15 P.M.
Total Kw.-hr. generated	33000	
Hp.-hr. producers rated capacity in use	40800	Storage cells all checked O.K. Smith
Kw.-hr. per producer hp.-hr.	0.87	Ignition set commutator turned down
Load factor of generators in use	92.4%	
Load factor of station capacity	76.38%	#4 Main bearing taken up is O.K. Truby

Capacity in use. Producers - - - - - Generators ——— Load in kw. — - — - —

Use back of this report for notes.

Plant superintendent ....

Fig. 3. Report Sheet for Producer Gas Plant

❊

Safeguards around Machinery

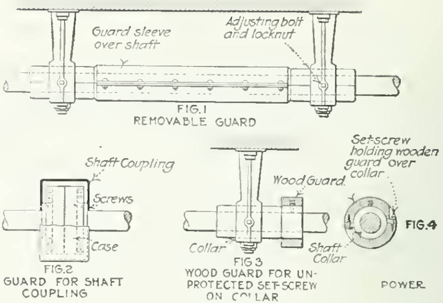
Suitable guards should be placed around all moving parts of machinery with which an attendant or workman is liable to come in contact and receive injury. In some cases a revolving shaft is not considered dangerous until some one in injured, and such accidents are numerous.

In a manufacturing plant recently visited, it was surprising to find that all the shafting had removable guards between the hangers, as illustrated in Fig. 1. Some were cast iron and others of considerable length were heavy sheet iron, made in halves and bolted togther at the flanges on the sides; they were attached to the bearings with screws.

Wooden collars were placed on the inside, surrounding but not touching the shaft, so that the guard can not be bent in against the shaft. Fig. 2 is a guard over a shaft coupling and is attached to it by screws, and revolves with the shaft, but as the outside surface is smooth, there is but little chance for clothing to catch on it.

A better way would be to have the guard made large enough to clear the coupling and attach it to the end of the bearing. The end of the guard next to a pulley can be supported by a screen guard by the side of the pulley, which will also guard the attendants from the pulley and belts. Where belts or ropes pass through floors or rooms they should be boxed in. Sufficient space should be allowed between two pulleys for the belt to lay flat, should it come off, to prevent its becoming entangled and break the belt or pull down the shafting.

A belt hook should be made on which to hang the belt when not in use, as it will be badly worn if allowed to hang on a revolving shaft. All keys or feathers should be covered with a guard. Unprotected setscrews on collars can be covered with a wooden guard, Fig. 3, made in halves and clamped together by screws. Fig. 4 is an end view of Fig. 3.



Guards around Line Shaft

Power-Plant Economies[*]

SYNOPSIS—General conditions affecting economical operation of the electrical and mechanical equipment of an office building.

Primarily, the building manager is responsible for the power plant if he has full power, and the operating engineer, who is directly in charge of the engineering equipment of the building, is responsible to the manager for its satisfactory operation. This phase of the manager's responsibility is important, because the difference between first-class and careless or indifferent operation by the engineering department may amount to thousands of dollars each year. In either case, it constitutes a gain or loss which is invisible to anyone not thoroughly trained in operating engineering, unless by comparison with previous years. A manager knows the amount of soap or labor required to properly clean 1000 sq.ft. of floor area in his building, but in how many instances does he know the pounds of steam which should be required in the building per month? To a considerable extent, he is dependent upon the honesty and capability of the operating engineer, because a building manager is not required or expected to have a thorough knowledge of engineering. It is therefore his duty to select an engineer who will operate the plant at maximum efficiency.

The field from which a selection might be made is broad and, not infrequently, the choice is unfortunate. The manager does not become aware of his error unless possibly by comparison with the records of previous or subsequent occupants of the same position. The man selected should have a proved record for honesty and engineering ability, and if these qualifications are not known to the manager, a method of inquiry might be adopted similar but more searching than that employed when determining the financial responsibility and general reputation of a prospective tenant. An irresponsible tenant may possibly cost the building a month's rent, while an incompetent engineer may cause a loss many times greater before being detected. Clean records in engineering, like those of business, will bear the closest examination, and the man whose experience proves him capable of successful economical management of a building's engineering equipment is reasonably certain to operate another plant similarly.

With the constant increase in the size of the modern skyscraper there is a corresponding increase in the size and complexity of the engineering equipment, which it is reasonable to suppose should require a similar degree of increase in skill and ability on the part of the man who is engaged to operate the plant. Other qualifications of no less importance than experience and education, which must be possessed by a successful engineer, are the ability to properly handle men and a reputation for honesty.

The measures to be adopted in the selection of such an engineer are rarely ever followed, it being considered unnecessary to do more than to fix a price, which is often too low, and induce some applicant to accept after a brief examination of his record. This is a chance method and the results are naturally problematical. Occasionally it so happens that an employer takes an engineer purely on a price basis and suffers accordingly. He alone is at fault, not the engineer, regardless of what the results may be, inasmuch as he has placed a premium on dishonesty and inefficiency.

In any successful manufacturing enterprise of today requiring labor, machinery and materials, the utmost care and attention are given by experts in this particular line to the proper construction of the building which is to house the industry; to the selection of the machinery best adapted to the requirements and to its proper arrangement to avoid unnecessary handling of materials, minimizing the labor.

The engineering equipment of a modern building is not generally looked upon as a manufacturing establishment. In the final analysis it is just this, and nothing more. The raw materials are coal, or other combustible, air and water, the finished products being light, heat and power in various forms according to the requirements of the building.

Eliminating operation, the ultimate degree of economy of the building power plant, like its parallel the manufacturing establishment, is dependent upon proper housing of the machinery and appliances; the selection of the kind, type and sizes of machines best adapted to meet the requirements and upon such arrangement of this equipment as will reduce the labor.

Owners and managers should realize that the space allotted to the machinery of the power plant has an appreciable effect on the efficiency at which it can be made to operate. It is of necessity usually at or near the lowest level of the building and, in many instances, to reduce the cost of excavation, the space is crowded and lacks sufficient head room. The boiler room is frequently so proportioned that the piping and valves overhead are cramped against the ceiling so closely that it is impossible to work in this space without physical discomfort.

Often the safety valves are attached to the ends of the boiler drums and depressions made in the ceiling to permit removal of the caps. The men are required to work over the boilers in a temperature around 150 deg., crawling over or under hot pipes, and the tools must be handled with gloves to prevent burning the flesh. If those responsible for these conditions were compelled to endure them for a short time, the working space over and around boilers would be much more habitable in the near future, regardless of the additional cost of excavation. It is generally recognized that better work is accomplished under reasonably comfortable conditions, so that, in the interest of maintenance and economical operation, attention should be given to making habitable the space housing the power manufacturing equipment and of such character as to cause an almost unconscious incentive for neat, clean conditions.

To secure the highest degree of economy in operation there are certain sizes and types of machines and appliances best adapted to the needs. The selection of the proper equipment calls for men of experience and training. Here the owner's or manager's responsibility is again involved, for he must choose the man who is to select the power-plant equipment.

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[*] Abstract of a paper read by F. K. Boomhower before the National Association of Building Owners and Managers, Duluth, Minn., July 15.

After reaching the decision to erect a building on a certain location, the usual course of procedure is to engage an architect who is told the type of building desired and the amount of money available for this purpose. He proceeds to design a building to meet the approval of the owner, which when completed shall not exceed the amount appropriated and still be a credit to the owner as well as an example of the skill of the architect. This is a commendable ambition and one to which no objection may be raised were it not for the fact that the architect is rarely a good engineer. In his struggle to obtain as much building as possible for the amount of money at his command, he often subordinates vital features of the engineering equipment to structural details or architectural design—in other words, he places æsthetics before engineering.

Nearly all architects have their own engineering departments, which enables them to handle the building and its equipment complete throughout construction. Naturally, this department is largely dominated by the architectural end, and when deciding on the final plans and specifications, the cost to fall within fixed limits, the engineers are called upon to make the greater percentage of reduction.

FALSE ECONOMY

This often leads to a corresponding reduction in the economy of operation, because such reductions must be made largely by the use of lower-grade machinery and appliances. For example, take the item of gate or globe valves used on steam and water lines. A valve of certain size may be purchased for $1.98; another grade of the same size and working pressure may cost $5. To many owners, managers and architects they appear very similar. They are of the same color, the same general shape, are built for the same purpose, and they cannot understand why the cheaper valve is not practically the equal of the more expensive one for their particular purpose. If, however, these gentlemen were asked why they do not wear a pair of $1.98 shoes in place of a $5 or $6 pair, they could readily explain, yet both pairs are of the same color, the same shape, the same general appearance and for the same purpose. This inability to appreciate the difference in the value of the valves is due, of course, to a lack of experience in work involving the handling and maintenance of this equipment. To the engineer who is familiar with this line of work, the relative values are easily perceptible, though difficult to explain to anyone untrained in this direction, especially if unwilling to be convinced, as when a reduction of initial cost of installation is involved.

Another feature of importance rarely mentioned in specifications is the packing on high-pressure gate and globe valve stems. These are usually packed by the manufacturer with the cheapest kind of material; if not, the contractor proceeds to do the work with a similar material. Neither of these men is at fault because he is not required by the terms of contract or specifications to do otherwise. Flange joint packing may be purchased as low as 30c. per lb., while a first-class article will cost around $1.15 per lb. In a comparatively short time the joints must be renewed at a cost much greater than the price of the original defective gasket.

A similar omission is the failure to require all pump valve stems and other small rods to be provided witn a packing known to be satisfactory and durable. These matters are not usually thought of sufficient importance for serious consideration, but in a plant packed in an indifferent manner the operating engineer must soon do the work which should have been cared for in the specifications.

TYPE OF ENGINE

The original cost of the power plant equipment may be reduced by installing high-speed engines instead of the moderate or slow-speed type, and without appreciable change of economy in the use of steam. This step carries with it a corresponding decrease in the cost of generators in the case of direct-connected units. No special objection can be raised except that from an operating standpoint the engineer who has handled both the high- and moderate- or slow-speed types is almost invariably an advocate of slow speed, because he knows this type is more easily operated and gives less trouble. The oldest engines in successful operation today are in the slow-speed class.

It may be said with much truth that the present tendency is toward higher speeds, but this should be charged to competition rather than to increased economy and life. Then owners and managers have discovered that the higher the speed of any given size of unit the less the floor space required and consequently less excavation and concrete and more space is available for some other purpose.

Engines are usually required by specification to operate at a minimum steam consumption, are nickel trimmed, equipped with all the necessary extras and finished in a fancy coat of paint. Working alongside these same engines are steam-driven auxiliaries in the form of pumps frequently outnumbering the engines two to one and struggling along often at too high a speed, blowing steam to the four winds and leaking in the valves and stuffing-boxes. The specifications would have been quite as effective had they simply called for some iron castings bored full of holes, fastened together with machine steel rods and studs with hot-punched nuts to resemble the general form of a pump. There are certain conditions under which it would be unwise to require these auxiliaries to be of the highest possible grade, as, for example, when the exhaust may be used for heating. Under this condition, why should the engine be required to work to the last ounce of steam? In nearly all power plants, steam-driven pumps are worthy of more consideration than is usually allotted them by those responsible for the original installation.

The possibilities and results of reducing the cost of a power plant to a minimum are briefly indicated by the preceding, and although a volume of considerable size might be devoted to a discussion of relative values of the different machines and appliances, enough has been said to show that this subject requires and should receive careful treatment by competent men, and that it is for the best interests of the owner or manager to lend his support to the one whom he has selected to decide upon what shall be installed.

BOILER ROOM LAYOUT

Another feature of the original installation having an important bearing on economy is the arrangement of the various parts. The boiler rooms of practically all buildings of the type under consideration are on the lowest level. Coal in most cases may be delivered at grade and, in addition, is sometimes received from a tunnel or subway. By a careful study of the situation the boilers and coal bunkers may be so placed that the coal will be carried by gravity from the delivery truck to the furnaces without any labor, power or machinery other than a traveling coal weigher. Coal-handling machinery is expensive, and a constant source of trouble and expense to operate. In the majority of office-building or hotel plants, this equipment is unnecessary unless coal is taken from a level below the bunkers. Occasionally it is impossible to obtain such a layout due to insufficient depth from grade to the boiler-room floor, the headroom being limited on account of the additional cost of excavation, retaining wall and footings. Owners and managers should remember that after installation the only expense attached to this additional cost is an annual 4 or 5 per cent., while with the alternative, is the original cost of installation with its 4 or 5 per cent., power to operate, labor, repairs and depreciation.

The proper arrangement and selection of ash-handling machinery is usually a difficult problem in plants which are below grade, because the ashes must be collected from beneath the various furnaces and delivered to a bunker or wagon at ground level. Where it is possible to deliver to a tunnel below the boilers, the operation becomes simple. Each building presents a different set of conditions which must be skillfully treated to obtain a durable operating system, but there can exist no satisfactory reason from an engineering standpoint for the clumsy ways coal and ashes are handled in some buildings.

THE AIR SUPPLY

Another of the raw materials necessary for the manufacture of power is the oxygen which is obtained from the air. It is free and just as essential as coal or water, yet often proper provision for feeding the furnaces with this material is not made. The fires are partially choked, receiving air by accident rather than design. The accident is in the form of a stack, which must of necessity extend above the building, thereby creating sufficient draft to overcome the resistance offered to the air flowing to the furnaces through doors, windows and other openings.

The general impression among those who have not studied the subject is that the fires do not require much air; that it is unnecessary to give any consideration to this point. Just how trifling the question is may be learned when it becomes known that to burn coal at the rate of 40 tons per 24 hr. usually requires in round numbers 18,000 cu.ft. of air per min. This may account for the strong draft in the openings leading to some boiler rooms.

A part of this air at least, and in some cases all of it, should be forced in by fans or permitted to flow free from the exterior of the building to the engine room through special ducts, and from there to the boiler room. In some cases the exhausting power of the stack may be sufficient to provide the necessary air change, but in no case should the boiler room be under less than atmospheric pressure.

Engineers familiar with power-plant operation are aware that the owner of a plant containing inferior equipment ultimately pays more than the price of a first-class installation. As they are just as desirous of accomplishing work which will be a credit to their ability as is the architect, and it is to be regretted that owners and managers are usually not as capable of judging engineering features as architecture. The economical operation of a building involves real engineering, and ability and experience are required. If the manager adopts the suggestions given in selecting the man who is to install or operate the plant, and grants him proper support, economical operation will be insured.

Cooling Effect of Evaporation

An interesting experiment may be easily performed to demonstrate the cooling effect by evaporation, in the following manner:

Take a watch glass or any other wide and shallow receptacle of thin material, set it in a depression in a cork containing a few drops of water, then fill the watch glass about half full of ether. By directing a steady current of air through a tube or straw on the surface of the ether, its evaporation will be so rapid that the water will be frozen in a short time.

The reason is, that whenever a vessel is only partly filled with a liquid, the remainder of the vessel always contains some of the substance in a gaseous form called vapor. The rate at which evaporation proceeds depends largely upon the amount of vapor already present over the liquid.

If the vessel is closed, it is found that at any one temperature, evaporation will continue until the vapor exerts a certain pressure on the surface of the liquid, known as the vapor tension at that temperature. Evaporation does not cease, however, but rather condensation equals evaporation.

Therefore, dispersing the vapor by a jet of air, or removing the pressure over the fluid by a vacuum pump and extending the area of the surface exposed to such action, tends to increase the evaporation and cooling effect.

Regulation on 150,000-Volt Line

In a paper read at the Pacific coast meeting of the American Institute of Electrical Engineers, Sept. 9 to 11, Edward Woodbury gave an interesting account of the regulation employed on the transmission system of the Big Creek Development of the Pacific Light & Power Corporation.

This development, it will be recalled, employs the highest transmission voltage yet attempted, namely, 150,000 volts, the distance to Los Angeles being 240 miles. A total head of 4000 ft. is utilized in two steps, about 4½ miles apart, each of the power houses at present containing two 17,500-kv.a. generating units.

The inherent regulation of the transmission line alone, without terminal equipment, is from 10 per cent. above power house voltage at no load to 20 per cent. below at full load; and the effect of the transformer inductive reactance at the generating end practically doubles the boosting at light load. Also, the self-exciting characteristics of the generators, when supplying charging current only, tend to produce abnormal voltages at no load.

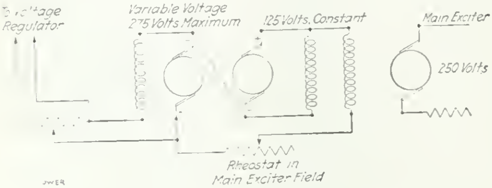

Voltage Regulator
Variable Voltage 275 Volts Maximum
125 Volts, Constant
Main Exciter
250 Volts
Rheostat in Main Exciter Field
POWER

FIG. 1. METHOD OF CONTROL IN PLANT NO. 1

A constant potential system is maintained by the use of two 15,000-kv.a. synchronous condensers at the receiving end and automatic voltage regulators, one for each generator and each condenser.

In one of the generating stations, the excitation system consists of three units, the main exciter and two auxiliary exciters, the latter connected in series opposition, as indicated in Fig. 1. The auxiliary units excite the field of the main exciter and are designed to generate at 125 to 275 volts, respectively. With a potential regulator on the 275-volt machine arranged to prevent a reversal of the field in the 125-volt set, the voltage applied to the exciter field may be changed from that required to give maximum excitation to zero excitation.

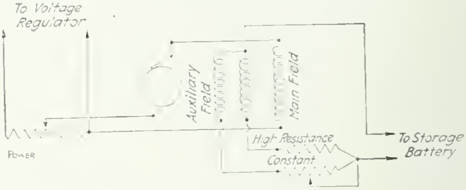


FIG. 2. METHOD OF CONTROL IN PLANT NO. 2

At the other station, the generators are excited directly by 200-kw., 250-volt exciters, the main fields of which are controlled by a new type of alternating-current automatic voltage regulator, which has no direct-current magnet and which can therefore be adjusted to reduce the exciter voltage to zero. The exciters on this system have three shunt windings on the field, as shown in Fig. 2. One auxiliary field is provided to give the reversed excitation necessary to hold the voltage down when charging the line, the current being supplied to this field, through a variable resistance, by means of a storage battery. The other auxiliary field, which is solely for the purpose of maintaining the correct polarity, also takes its current, which is small, from the same storage battery.

A reduction of the excitation to zero by means of the potential regulator has not been necessary at the generating stations, but operation of the synchronous condensers at the receiving station, over the range required, would not be feasible without a complete reduction of the exciter voltage.

With 150,000 volts at the receiving end of the line, the charging current is about 10 per cent. overload for one generator. With normal voltage of 6600 volts at the generator, the charging current overloads the generator 65 to 70 per cent. Hence, in normal operation, a line is usually energized by using two generators, under which condition a small field excitation in the normal direction is required. Abnormal conditions sometimes make it necessary to charge the line from a single generator, until the condensers at the receiving station can be started.

The self-exciting characteristics of the system with leading current are such that in one of the generating stations a single 6600-volt generator, when connected to an unloaded line without its condenser and run at normal speed with the field switch open, would excite itself to 7000 volts, corresponding to 176,000 volts on the transmission line at the generating station, and demand from the generators 34,000 kv.a. and 850 actual kw.

Many European Nations at Panama Exposition

In answer to numerous inquiries, President Charles C. Moore of the Panama-Pacific International Exposition, to open in San Francisco on Feb. 20, 1915, has issued the following statement:

One month ago, the decision of the Panama-Pacific International Exposition management not to postpone was first published. The development of events since then in their relation to the exposition all tend to confirm the wisdom of that original decision.

At the time the decision was made no word had been received from any foreign nation as to the effect on its plans caused by the European war, but it was hoped that at least those nations not fighting would go on with their plans. Later developments have proved that hope well founded; in addition, we have definite assurances from France, Italy, Turkey and Japan that their intentions are unchanged. Holland has added $300,000 to her original appropriation, Italy has ordered work on her building and exhibits rushed, Japan has asked for and received an increase of space, and the

Argentine Republic has increased its appropriation from $1,250,000 to $1,750,000.

We shall undoubtedly lose some of the promised exhibits from Europe, but not by any means all of them nor the most important of them. Both Germany and Great Britain will be represented by individual exhibitors or by associations thereof. We shall undoubtedly lose some of the promised entries by European champions in the athletic events, but the international character of those events will not be lost. We may lose some of the art treasures promised us for the Fire Arts Building, but we shall gain others because of the war.

Of compensating gains we have many. There is a very sharp demand for space from the manufacturers of this country, of South America and of the European nations not at war. The exposition suddenly becomes an important factor in an extraordinary economic situation. It is seen to be the one, great, easy, efficient way by which American made goods can be brought to the direct attention of the distributors and consumers of South America and the Orient. The latter are coming here in force in 1915 to make the new individual and commercial connections forced by the war.

As regards attendance, every transportation expert confirms the opinion that a continued European war is likely rather to increase travel to California in 1915 than to reduce it.

The exposition is 92 per cent. ready today. It will open Feb. 20, as planned, and it will be the most beautiful and most interesting exposition ever seen. There is no reason to believe that its success, in any phase, will be any less than that which was so certain before the European war broke out and it is certain to be even more important commercially than was ever dreamed.

Boiler Makers Meet to Forward Adoption of Uniform Boiler Laws

On Tuesday, Sept. 29, about sixty representatives of the largest and most important boiler manufacturing interests of the United States met at Pittsburgh to formulate plans and initiate activities to bring about the adoption by the various states of laws putting into effect the Code of Boiler Rules, which the committee appointed for that purpose will report to the fall meeting of the American Society of Mechanical Engineers.

An executive committee consisting of Thomas E. Durban, of the Erie City Iron Works, representing the fire-tube, Isaac Harter, Jr., of the Babcock & Wilcox Co., representing the water-tube, and A. B. Goodling, of the A. B. Farquhar Co., Ltd., the traction and agricultural boiler interests, was appointed to represent the boiler manufacturers in conference with the American Society of Mechanical Engineers committee and to direct the efforts of the boiler makers toward bringing the code into use. Abundant financial support was assured.

Industrial Education

The National Association of Corporation Schools has received a report from its subcommittee on the scope of activities for 1914 and 1915, which was adopted by the executive committee, Sept. 1, 1914. When the recommendations in this report are carried into effect, the association will have syllabi of courses to send to corporations asking for data as to the subjects to be taught.

The committee on safety, hygiene and coöperation will distribute printed matter in the shape of summaries of the work in safety and hygiene in industrial corporations, and make recommendations as to instruction along those lines.

The association also purposes to prepare bibliographies on the subject of service annuities, profit-sharing plans, sick and death benefits and savings funds.

The committee on public education is to investigate and ascertain to what extent the industries are at present coöperating with public schools in the various cities and to make a compilation of the experiences of the industrial corporations which have coöperated with the public-school systems. Further, it is to show in what additional ways the two may coöperate, and special attention will be given to collecting data regarding general educational courses in which the experience of industries has shown the public schools to be particularly weak, with reference to fitting a person to enter industrial life. Finally, the committee is to ascertain to what extent tho industries find it necessary to duplicate the educational work of the public schools, and if possible investigate in several localities to find out whether the public schools are willing to conduct courses for or in connection with the industries to supply this inefficiency.

The committee on allied institutions will compile names of all organizations which include in their activities, or are contemplating doing so, the study of industrial educational work, learning the policy and scope of each of these institutions, making recommendations to the executive committee as to the ways in which the association can coöperate with these organizations, and to establish relations with the Librarians' Association with a view to having a selected list of books and industrial subjects placed in public libraries.

A new committee, to be known as the committee on employment plans and allied subjects, is to be formed which will take up the subject of employment with the allied topics of vocational guidance, promotion, discipline, physical examination, etc.

The several different committees on special schools, including trade apprenticeship, special apprenticeship, accounting and office work, advertising, selling and distribution, will prepare general syllabi that may be made a basis for courses by corporations desiring to undertake educational work for their employees. Both special and general subjects will be taught. Which general subjects should be included, however, must be determined by each corporation in accordance with the extent to which their new employees have been properly prepared in the public schools. It is recommended that each of the four committees should make a compilation of the work of at least a representative number of large corporations which are conducting educational work on behalf of their employees. The best compilation should include results which have been obtained. Finally, each committee is to look into the activities of such institutions as the Alexander Hamilton Institute, the International Correspondence Schools and the Sheldon School, to determine to what extent the work of these institutions can be used profitably by the corporation schools.

The executive committee, in approving the report, will put on foot a piece of splendid work for the betterment of conditions among those now engaged and soon to be engaged in the various industries. It is a work deserving of a great deal of attention and the hearty coöperation of all corporations. The report was signed by G. B. Everitt, F. C. Henderschott and E. J. Mehren, chairman.

Tube Failure Interrupts Service

Due to a series of tube failures in three boilers at the Livingston plant of the Richmond Light & Railroad Co., on Saturday afternoon, Sept. 26, trolley service on Staten Island, N. Y., was completely held up for over an hour and the lighting and commercial service for about seven hours. Moreover, two of the engineers were painfully scalded by the steam and water from the first tube which opened up.

The boilers, which were temporarily put out of service are practically new ones of the B. & W. type and the tubes were seamless drawn steel. The complete tieup of service was brought about by an unfortunate combination of circumstances. Aside from the tube failures in three boilers within a short period, two new boilers which have just been added were not yet ready for service and four of the old boilers, which were held in reserve, are allowed only 130 pounds pressure as against 200 pounds on the new boilers. With this reduced pressure it was difficult to keep the turbine auxiliaries up to speed and thus hold the load on the turbines.

PERSONALS

H. V. Neff, chairman of the Ohio Board of Boiler Rules, was present at the hearing of the A. S. M. E. committee of uniform boiler laws with two other members of the Board and testified to the interest of that body in the work upon which the committee is engaged.

OBITUARY

FRANK BAER

In attempting to remove a live wire that had dropped into Pennsylvania Ave, Frank Baer, 40 years old, superintendent of the Kutztown Electric Co., was instantly killed on Sept. 21, at Kutztown, Penn. During a heavy shower, the wire was blown down. Mr. Baer was attending a church meeting at Grace United Evangelical Church, where he was notified of the accident. He hurried to the scene with insulated pliers, but as he touched the wire the pliers were knocked from his hands and he was hurled to the ground. Word was sent to the plant and the power was turned off.

Baer was removed to a nearby porch, where physicians said death was instantaneous.

TRADE CATALOGS

McCord Mfg. Co., Detroit, Mich. Catalog. Force feed lubricators. Illustrated, 30 pp., 6x9 in.

The Vilter Mfg. Co., Milwaukee, Wis. Catalog. Corliss engines. Illustrated, 40 pp., 7x10 in.

John O'Brien Boiler Works Co., St. Louis, Mo. Pamphlet. O'Brien-Hawley down-draft system of smokeless combustion. Illustrated, 12 pp., 6x9 in.

The Lagonda Mfg. Co., Springfield, Ohio. Catalog R-2. Multiple strainers. Illustrated, 20 pp., 7½x10 in.

Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3024. Ingersoll-Rogler valves for air compressing cylinders. Illustrated, 28 pp., 6x9 in. Form No. 3030. Class ER-1 Ingersoll-Rogler air compressors. Illustrated, 20 pp., 6x9 in.

Coen Company, San Francisco, Cal., Catalog. Fuel oil burners. Illustrated, 32 pp., 8x11 in.

National Tube Co., Pittsburgh, Penn. Bulletin No. 7D. Regrinding valves. Illustrated, 8 pp., 8½x11 in.

Smooth-On Mfg. Co., 572-74 Communipaw Ave., Jersey City, N. J. Smooth-On Instruction Book No. 15. Iron cements, iron paints and corrugated iron gaskets. Illustrated, 104 pp., 4½x6½ in.

Essex Rubber Co., Trenton, N. J. Catalog K. Packings. Illustrated, 50 pp., 6x9 in.

The Industrial Instrument Co., Foxboro, Mass. Bulletin No. 82. Liquid level gages. Illustrated, 20 pp., 8x11 in. Bulletin No. 88. Recording gages. Illustrated, 32 pp., 8x11 in.

National Tube Co., Pittsburgh, Penn. Bulletin No. 9C. Some tests of Kewanee unions. Illustrated, 8 pp., 8½x11 in.

The Hill Clutch Co., Cleveland, Ohio. Catalog No. 11. Power transmission machinery. Illustrated, 224 pp., 6x9 in.

The Engineers Appliance Co., Cleveland, Ohio. Catalog No. 3A. Hydromatic valves, steam traps, low pressure water feeder. Illustrated, 20 pp., 6x9 in.

Tate, Jones & Co., Inc., Pittsburgh, Penn. Catalog. Appliances for burning fuel oil. Illustrated, 32 pp., 8½x11 in.

Armstrong Cork & Insulation Co., Pittsburgh, Penn. Booklet. Nonpareil insulating brick for boiler settings. Illustrated, 3½x6 in.

Moffat Feed Water Heater and Purifier Co., Detroit, Mich. Catalog. Combined feed water heaters, purifiers and oil extractors. Illustrated, 24 pp., 6x9 in.

Gifford-Wood Co., Hudson, N. Y. Catalog. Ice and coal handling machinery. Illustrated, 180 pp., 6½x10 in.

BUSINESS ITEMS

L. J. Wing Manufacturing Co., Ninth Ave. and 14th St., New York has just issued Bulletin No. 28 which illustrates and fully describes the Wing Fans. Copies are sent on request.

It is interesting to note that the sales of the Northern Equipment Co., Erie, Penn., were practically doubled within the past year—and to take care of the rapidly increasing business the company has purchased the shops formerly occupied by the Olds Pump Works of Erie. Penn. Two new sales agencies have also been added—Scholey and Company, Ltd., 151 Queen Victoria St., London, Eng. and Thermal Efficiency Co., 716 Finance Bldg., Kansas City, Mo.

The C. & G. Cooper Company, Engine Builders, Mt. Vernon, Ohio, have had good business for August in their steam and gas engine departments. Among orders received is one from the Medina Gas & Fuel Co. for a 950 brake-horsepower twin tandem gas engine driven compressor, to be installed in the Mansfield, Ohio, station. This will be the third Cooper unit in the plant. The Ohio Fuel Supply Co. have also ordered three 475 b.-hp. single tandem gas engine driven compressors, to be installed in their Perrysville, Ohio, plant.

The Lagonda Manufacturing Co., of Springfield, Ohio. has just published a complete 20-page catalog descriptive of their Multiple Water Strainers for power plant and pumping station intake lines. These strainers are of the multiple straining basket type which can be easily and quickly cleaned without interruption to the flow of water. The new catalog is entitled "The Lagonda Multiple Strainer," edition R-2, and will be sent upon request.

The American Engineering Co., Philadelphia, Penn., has just published a new book on the Taylor stoker, which every man interested in the subject should have. Page after page of excellent illustrations of installations, complete details of construction and operation, several pages of names of Taylor stoker users. It is a handsomely prepared catalog, well worth reading, and is sent free on request.

Elliott Co., Pittsburgh, Penn., has appointed William A. Day Chicago district sales manager. Mr. Day was formerly sales manager of the Erie City Iron Works in the Chicago district, and is not only well known as a salesman, but as an engineer as well. The Elliott Co.'s Chicago office, in charge of Mr. Day, will be as heretofore, at 527 Monadnock Block.

Elliott Co., Pittsburgh, Penn., has appointed Mr. George Gray, of Boston, Mass., sales manager for the New England district. Mr. Gray is well known in the New England territory, and was connected with the Elliott Co.'s interests several years ago. The office of the company, in charge of Mr. Gray, will remain at 954 Oliver Building, Boston, as heretofore.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Germania Mills, Holyoke, Mass., will construct a power house, 60x100 ft. with an ell.

The Bon Ami Co., Manchester, Conn., manufacturer of cleaning compounds, has bought a site near its present plant and will make extensions, the first of which will be a power plant of sufficient capacity to supply the plant for some years to come.

George C. and Arthur M. Morgan, Engrs., 111 West Monroe St., Chicago, Ill., have been engaged by the City Council of Kittanning, Penn., to prepare plans for the installation of a municipal electric-light plant and water work. The estimated cost is $125,000.

Roth & Co., Denlka Bldg., Philadelphia, Penn., are preparing plans for the construction of a municipal electric-light plant for the Borough of Lewiston, Penn.

It is reported that the Mauch Chunk Heat, Power & Electric Light Co., Mauch Chunk, Penn., has purchased a site and will build a new substation.

SOUTHERN STATES

Press reports state that the city of Jacksonville, Fla., will install a 5000-kw. engine, to cost $60,000, in the municipal electric-light plant. W. H. Tucker is Supt.

Bonds for $10,000 were voted by the citizens of Pablo Beach, Fla., at a recent election, by the proceeds of which will be used for the construction of a municipal electric-light plant. The J. B. McCrary Co., Atlanta, Ga., is the Engr.

Bids will be received until Oct. 6, by the Mayor, Melville, La., for the installation of an electric-light plant.

The Bluegrass Motion Picture Mfg. Co., Glenarm, Ky., is in the market for generators, motors, etc., for a factory which it is equipping. George H. Kendrick is Mgr.

The Greensburg Loose Leaf Tobacco Warehouse Co., Greensburg, Ky., is in the market for power equipment for its prizing rooms.

At the November election the citizens of Princeton, Ky., will vote on the proposition of issuing $15,000 in bonds the proceeds of which will he used for the construction of a municipal electrci-light plant.

CENTRAL STATES

Bids will soon be received by Walter G. Franz, Union Trust Bldg., Cincinnati, Ohio, for a heating system for the isolation hospital to be erected by Cincinnati.

Bids will soon be received by W. A. DeVoss, Portsmouth, Ohio, for the installation of heating equipment in the new municipal school.

Press reports state that the Urbana Light Co., Urbana, Ohio, will enlarge its power plant. The company has obtained the contract for furnishing light to Woodstock, Ohio.

The Veedersburg Power Co., Veedersburg, Ind., has increased its capital stock from $100,000 to $125,000. Extensions will be made.

The Detroit Lumber Co., Detroit, Mich., will build a power house and garage costing $15,000.

Hiram Phillips, Consult. Engr., Third National Bank Bldg., St. Louis, Mo., has been retained by the Council of Sullivan, Ill., to prepare plans for the establishment of a municipal electric-light plant.

WEST OF MISSISSIPPI

Bonds in the amount of $7000 have been voted by the citizens of Aurelia, Iowa, the proceeds of which will be used for the construction of a municipal electric-light system.

The municipal power plant at Buhl, Minn., will be improved at an estimated cost of $50,000. Bonds for this purpose have been voted.

Bids will be received by the City Council, Lincoln, Neb., until Oct. 15, for making improvements to the electric-light plant and water system. Theodore H. Berg is City Clk.

Shade & Levesconte, Malta, Mont., contemplate installing an electric-light plant at Malta.

Improvements costing $17,000 to the electric light have been authorized by the Board of Aldermen, Kirkwood, Mo. The Board of Public Improvements will have charge of the work.

CANADA

The City Council, Quebec, Que., has authorized the construction of a boiler room on Beauport Road, estimated to cost $150,000. J. L. Pinsonnault, City Hall, is the Arch.

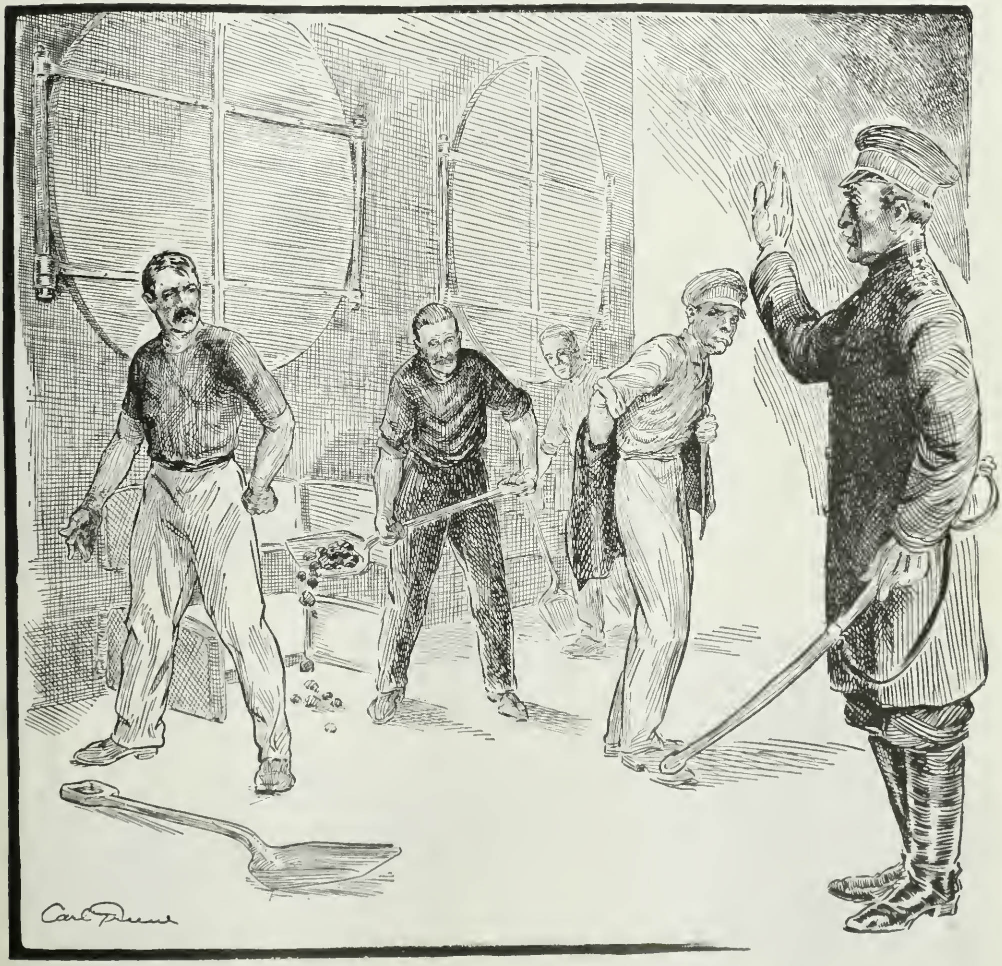
Press reports state that the United Gas & Fuel Co., Hamilton, Ont., will construct a coke and gas plant estimated to cost $1,500,000.

H. J. Glaubitz, Engr. Water-Works, London, Ont., is in the market for two waterwheels, turbine, pumps and motors.

POWER

Vol. 40 NEW YORK, OCTOBER 13, 1914 No. 15

What War Means



THE PARALYSIS OF INDUSTRY

Combination Electric and Ice Plant, Kentucky Traction and Terminal Co.

By Warren O. Rogers

SYNOPSIS—A combined electric and ice plant. Electric energy is generated by two 2500-kw. turbo-generators supplied with steam from four 1000-hp. water-tube boilers. The ice plant is a 75-ton capacity exhaust-steam system. Steam for the generator is taken from a 160-hp. turbine which drives a centrifugal pump supplying water to the steam condensers. The ammonia condenser, rectifier and weak-liquor cooler are of the atmospheric type and placed on the boiler-room roof.

⁂

Four years ago, or in 1910, the Lexington Railway Co., operated an antiquated power house in which were belt-driven railway generators, vertical steam turbines, etc. In connection with this plant was a 50-ton, steam-driven compression ice plant, all of which had been run about a year under the management of F. W. Bacon, vice-president, and A. A. Robertson, superintendent of production; then the firm of Sargent & Lundy was commissioned to build a new $500,000 power plant. The company was reorganized and is now known as the Kentucky Traction & Terminal Co.

The new plant, at Lexington, Ky., is one of the cleanest and most attractive in the South, and although it has a capacity of but 5000 kw., its layout arrests the attention of the visitor as soon as he enters.

Fig. 1 is a view of the plant from the rear. The structure is of concrete and brick, the concrete reaching on the boiler-room side to a level with the car track. The boiler and the turbine rooms are well lighted by the large windows.

Turbine Room

The two 2500-kw. turbo-generators, Fig. 2, are placed crosswise of the turbine room, with ample room for the operator to get about and to make the repairs. The plan and elevation, Fig. 3, show the general arrangement of the apparatus on the turbine-floor level. At the far end of the plan view is No. 1 turbine, with its 9 and 22 by 16-in. air pump. Next, there are three turbine-driven circulating pumps, two of which, placed crosswise of the room, are 16 in. in size and have a capacity of 8000 gal. of water per min. at 1000 r.p.m. Each is driven by a 160-hp., single-stage horizontal turbine. The third pump, placed lengthwise of the room in line with

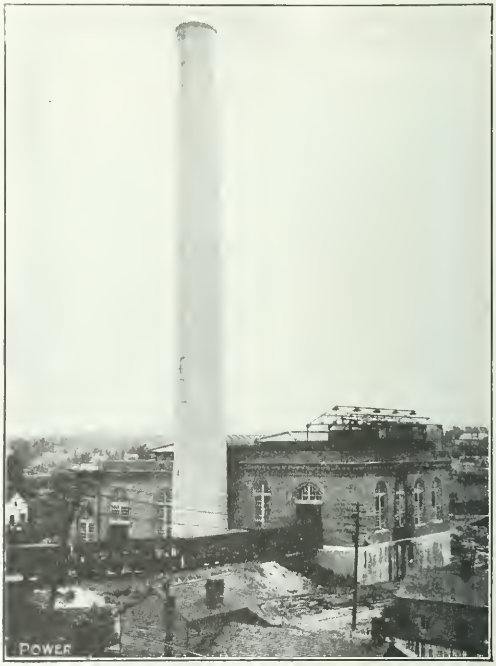


Fig. 1. View of the Power Plant from the Rear

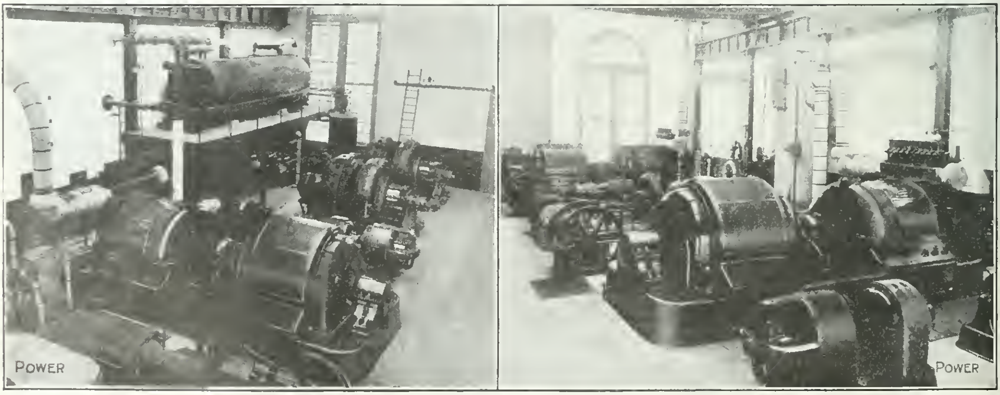
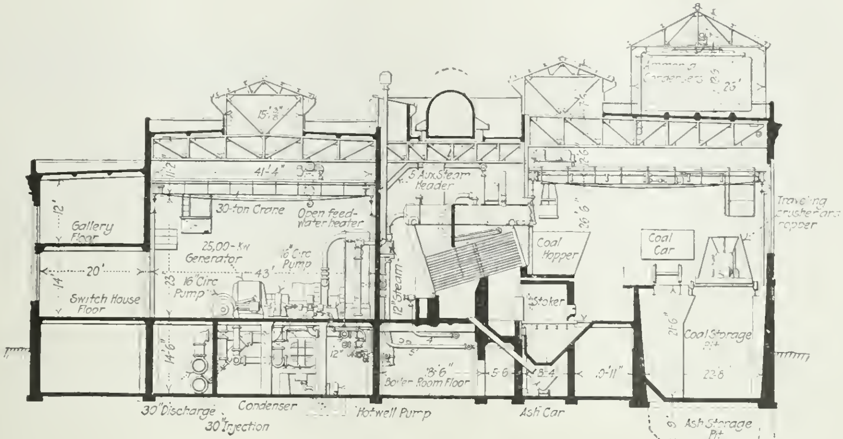
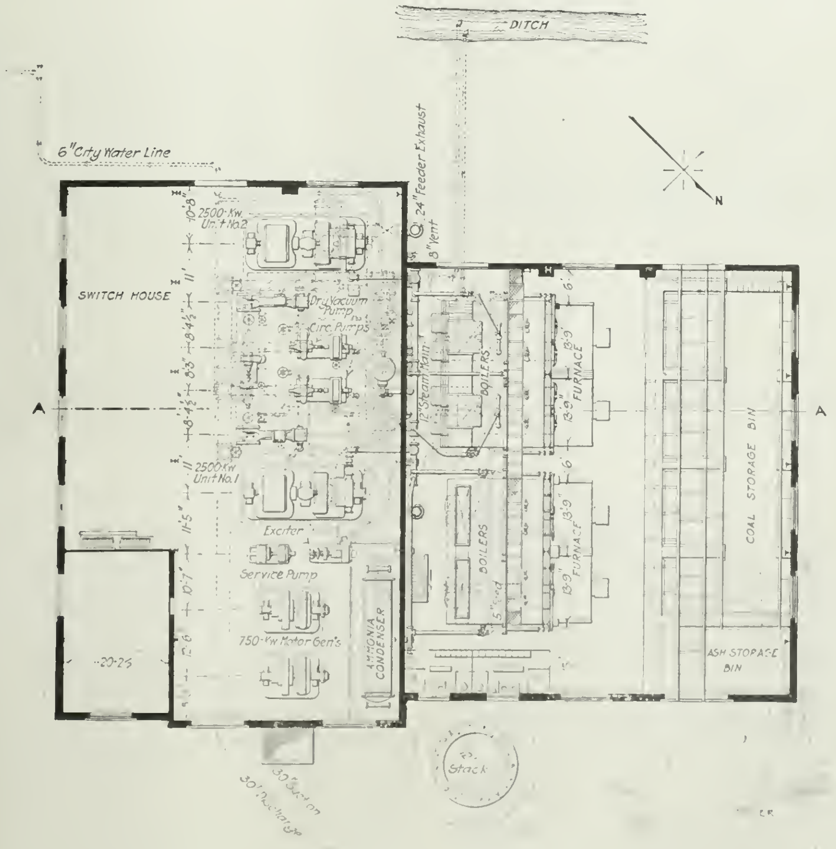


Fig. 2. Two Views of the Turbine Room, Showing the General Layout of the Various Units



SECTIONAL ELEVATION A-A



PLAN

FIG. 3. PLAN AND ELEVATION OF THE LEXINGTON, KY., POWER PLANT

the crank end of the two air pumps, is a 10-in. pump, with a capacity of 3000 gal. per min., and is driven by a 60-hp., single-stage turbine.

The second air pump is of the same size as that used with No. 1 condenser. No. 2 turbine comes next and lines up with No. 1 unit. At the right of No. 2 turbine are two exciter units; one is a turbo-generator set of 75-kw. capacity, 125 volts, at 3300 r.p.m., the other is an induction motor-generator set of 75-kw. capacity, 125 volts at 1165 r.p.m.

Two 1075-hp. synchronous motor sets deliver 600-volt current at 514 r.p.m. for street-car service in the heart of the city, the high voltage of the main generator being transmitted to substations for distant points.

Next to the wall separating the boiler and turbine rooms is a 14 and 8 by 15-in. duplex boiler-feed pump. When the plant was first built, there were two pumps, one on each side of the heater, but one has been and the one in the turbine room will be removed to the basement so that the turbine room may not be disfigured by water leakage around the pumps.

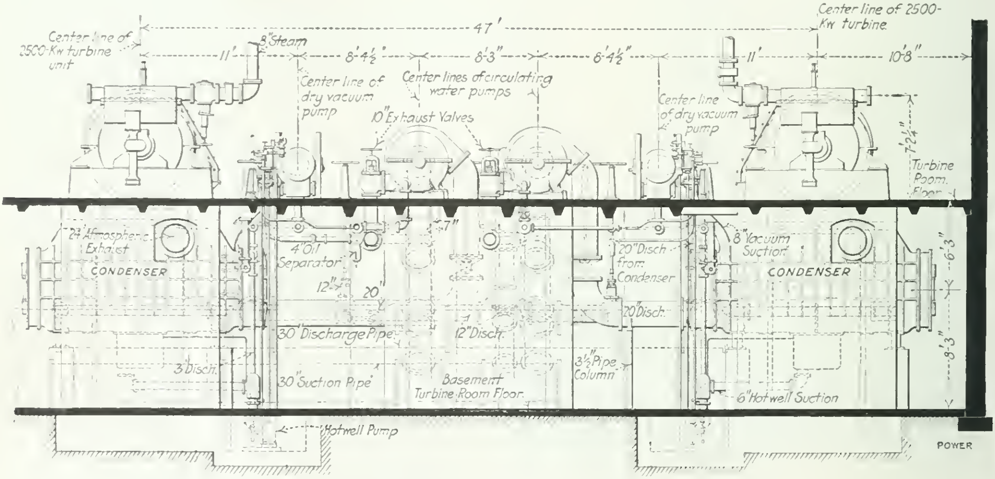


Fig. 4. Elevation of the Turbine and Pump Piping

At the head end of each main turbine is a vertical 6 and 10 by 12-in. hotwell pump, which removes the hot water from the condenser hotwell and forces it to the 4000-hp. open heater, next to the boiler-room wall. As only the steam cylinder of the hot-well pump protrudes above the turbine-room floor, all leakage from the pump end is drained directly to the sump. This is all of the apparatus in the turbine room except the ammonia generator and the aqua pumps of the refrigerating system, which is operated on exhaust steam from the auxiliary turbines. The system will be described later on.

Piping

With the exception of the boiler-feed pump, hotwell pumps and a few traps, the only other apparatus in the basement are the two surface condensers, each containing 7500 sq.ft. of cooling surface. This gives a ratio of turbine capacity to condenser cooling surface of 1 to 3. The condensers in the basement are at right angles to the main turbines. Exhaust steam enters the top of the condensers at the center through a 5-ft. diameter corrugated expansion joint. Condensate from the condenser passes to the hotwell through a 6 in. line and is pumped to the heater through a 3-in. pipe. Each turbine exhaust is connected to a 24-in. atmospheric exhaust extending through the basement to the boiler-room side of the partition wall, where it is run through the roof.

Water from the cooling pond flows by gravity through a 40-in. concrete pipe to a well in the power house from which a 30-in. cast-iron pipe runs to a point below the large circulating pumps and which are connected by 20-in. pipes with the main suction line. The discharge lines from these two pumps are each 20 in. in diameter and the suction line to the small circulating pump is 14 in. in diameter. The 12-in. discharge pipe connects with the discharge pipe of each of the large circulating pumps. Valves with extension stems and floor stands are so arranged that the small pump can be operated with either condenser, or in conjunction with either of the large pumps. The discharge and suction lines of the latter are also fitted with extension valve stems and floor stands.

Steam for the two main turbines is taken from the 12-in. main header in the boiler room, through 8-in. long-radius bend pipes. The auxiliaries take steam from a 5-in. auxiliary header in the basement, piped to the main steam header at each end. The two large and the small circulating pumps receive steam through a 3½- and 2½-in. line, respectively; the exhaust lines are 10- and 7-in., connected with a 12-in. exhaust header, piped to the open heater and to an 8-in. atmospheric exhaust. An elevation of the piping of the turbines and auxiliaries is shown in Fig. 4.

Owing to the scarcity of cooling water, a spray cooling pond has been built 612 ft. from the power plant. This is because the old reciprocating plant, now dismantled, was at the end of the old cooling pond, and as the new plant would require more pond area, an addition was made. The old and new ponds are divided by a dam; the two

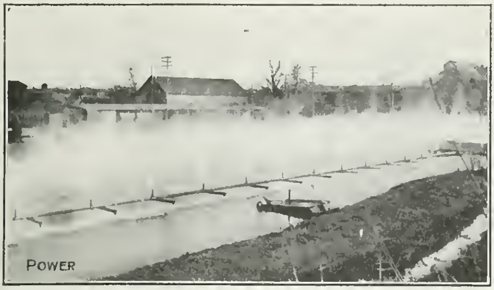


FIG. 5. SPRAY-COOLING POND, OLD PLANT AT THE RIGHT

combined are about 300 ft. long with an average width of 125 ft. and a capacity of 3,000,000 gal. In all there are 109 spray nozzles with a total capacity of 20,000 gal. of water per min., and cooling it 15 to 20 deg. A view of the pond is shown in Fig. 5.

BOILER ROOM

The boiler room contains four 1000-hp. water-tube boilers. Each has 5000 sq.ft. of heating surface and carries 200 lb. of steam superheated 125 deg. Dutch-oven furnaces are employed with automatic stokers 8 ft. 9 in. long and 12 ft. wide, a total of 105 sq.ft., or 1 sq.ft. of grate area to 47.6 sq.ft. of boiler-heating surface.

Above the stokers is a coal hopper, which is kept supplied by means of a 5-ton traveling crane and grab bucket. Run-of-mine coal is delivered to the boiler room in railroad cars, Fig. 1, and is unloaded into a 1000-ton coal-storage pit. Adjoining this pit is a second of the same capacity, over which a traveling crusher and hopper runs on a wide-gage track. It is driven by a 40-hp. mill-type motor. The crane is equipped with a 30-hp. closing motor, a 10-hp. running service motor, a 20-hp. bridge motor and a 40-hp. motor for hoisting.

The second bridge-wall of the boiler furnaces is centered under the first baffle-wall, and extends to the bottom of the furnace. Back of this bridge-wall is an outlet for discharging soot from the rear end of the boiler setting into an ash car on a narrow-gage track, built under the ash-pit hoppers, and running lengthwise of the boiler-room basement. The ash car is thus made to serve the double purpose of handling ashes and soot from the same track. Ashes are discharged into a concrete 75-sq.yd. storage pit at one end of the coal-storage pits, Fig. 3, and the accumulation is hoisted by the crane bucket and loaded into cars for final removal.

Each boiler is piped to the main 12-in. header by a 6-in. lead, which connects at the boiler end with the outlet from the superheaters. Feed water is supplied by two independent 5-in. feed lines, dropping to the basement from the main feed header back of the boilers and connecting with a second header in the basement, from which separate feed lines run to each boiler. The auxiliary feed lines run up and are brought over the top of the boilers to a header from which separate feed lines are piped to the boilers. This arrangement provides reasonably reliable service against feed-water failure and at the same time removes a mass of feed piping from the boiler fronts where it would interfere with repair work, etc.

Gases in reaching the smoke uptake from the furnace flow through three passes in the boiler and discharge at the top at the rear end into a 4x11-ft. lined steel uptake, having an area of 44 sq.ft. The main smoke flue, Fig. 6, on the roof, is made of sheet steel, lined with firebrick and is rounded on top. The flue is 8 ft. 6 in. wide and is 8 ft. 6 in. and 12 ft. 9 in. high at the small and large sections, respectively. This smoke flue extends the length of the boiler house and enters a concrete chimney 215 ft. high with a 12-ft. diameter at the top. This gives a stack area of 113 sq.ft., or a ratio of grate and stack area of 1 to 1.076.

The boiler tubes are kept clean by a system of tube blowers.

ELECTRICAL APPARATUS

On the turbine side of the building are the switchboard bay and gallery, which, with the basement level, gives three floors for the electrical control apparatus. The main switchboard, Fig. 7, is in a bay, upon which are mounted the necessary recording and indicating instruments, switches, etc. All high-voltage switches are operated by remote control. The circuit-breakers, oil switches and busbars are housed in brick compartments in the basement, Figs. 8 and 9.

REFRIGERATING APPARATUS

In conjunction with the electrical generation of power, byproduct ice is made. This is sold at retail by the company in Lexington and to ice plants in the neighborhood. During the winter months, when the local demand for ice is small, the company furnishes ice to its competitors in Lexington and to ice companies in the general territory.

The economical production of ice by the combined electric ice plant is due to the absorption ice system, which uses exhaust steam in the generator that has already performed work in the electric plant. The ice is shipped in the company's ice cars, which are run over the interurban lines leading to the surrounding country. Due to the constant demand for ice, the plant is operated at nearly full-rated capacity throughout the year. The operating cost per ton of ice is low.

The new power plant is about 600 ft. from the tank room and storage house. The new ice-storage house has

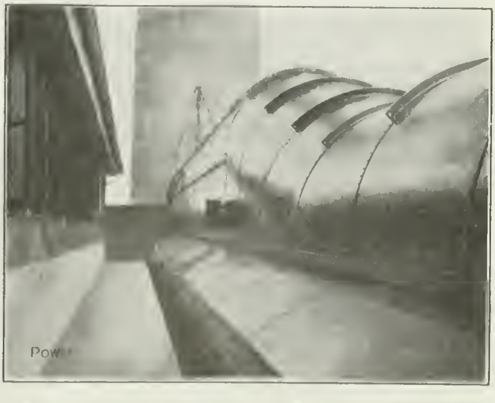


FIG. 6. SMOKE FLUE ON THE ROOF OF THE BOILER HOUSE

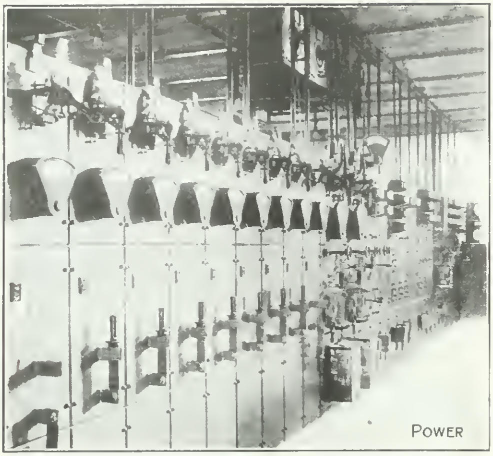
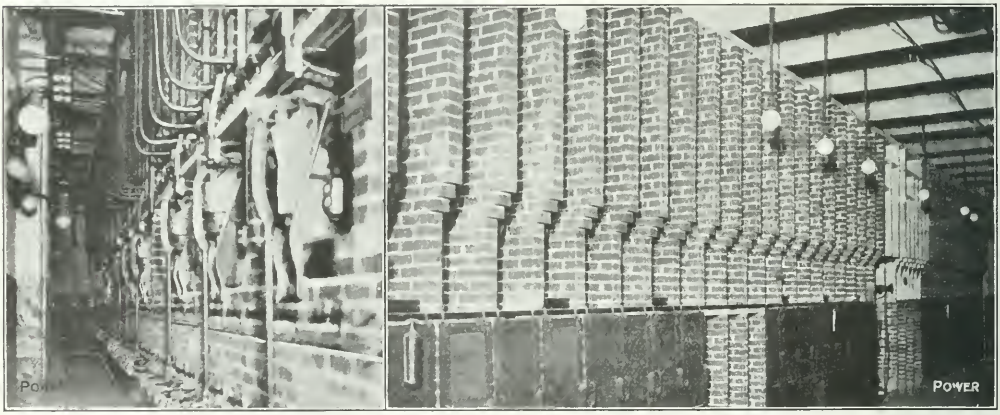


Fig. 7. Main Operating Switchboard



Figs. 8 and 9. Switches and Busbar Arrangement in the Basement of the Power House

a capacity of 5000 tons; it is constructed of two layers of 8-in. hollow tile, insulated with sheet cork. The building is 51 by 61 ft. and 68 ft. high.

The distance between the old and the new plants brought up an interesting and perplexing problem as to the type of machinery to put in. After due consideration, a 75-ton exhaust-steam, ice-making machine, capable of making 72 tons of ice on the two old tanks, each of 412 cans, was decided upon.

The generator of the ice plant is shown at the rear of the left view of Fig. 2, mounted on a platform. Ammonia gas is driven off from aqua ammonia and sufficient pressure is produced so that the gas, after being dried in the rectifiers, is condensed, making liquid anhydrous ammonia, which passes through a 1½-in. line to the old power house, where it is expanded through coils in the ice tanks. The expanded gas from these coils, after passing through the coils in the distilled-water-storage tanks, returns to the absorber on the roof through a 6-in. line. The atmospheric condenser consists of 28 stands of coils, each 10 pipes high; below are 28 stands of absorber coils, each 12 pipes high. Fig. 10 shows the coils as arranged on the boiler-house roof. Exhaust steam for the generator is obtained from one of the 160-hp. turbines driving the rotary pumps supplying water to the steam condenser.

The system is guaranteed to operate with the condensing water at 95 deg. F.; this has been exceeded. The temperature of the water averages 60 deg. in winter and goes as high as 103 in summer when the system operates at full capacity. The average summer temperature is 98 deg.

The exhaust steam from the 160-hp. turbine used in the generator of course creates a back pressure on the turbine, but this does not cause the steam consumption of the turbine to exceed 20 lb. per hr. per ton of ice during the summer months. During the winter, the increase is about 3 lb. per hr. per ton of ice, as the back pressure is decreased.

As the atmospheric condensers, absorbers, rectifiers, exchanger and weak-liquor cooler are on the roof and the generator at one end of the turbine room and elevated above a stairway, it was not necessary to make the build-

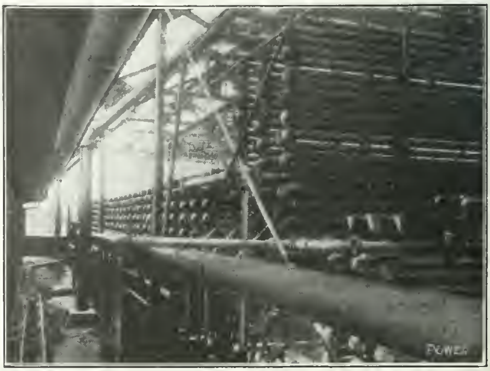


Fig. 10. Condenser, Rectifier and Exchanger on Roof of Boiler Room

PRINCIPAL EQUIPMENT OF THE COMBINATION ELECTRIC AND ICE PLANT OF THE KENTUCKY TRACTION AND TERMINAL CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbo-generators	Horizontal	2500 kw	Main units	1800 r.p.m., 200 lb. steam, 3 phase, 60 cycle, 4000, 2300 volts	General Electric Co.
1	Motor-generator	Induction, d. c.	75 kw	Exciter for main turbines	1165 r.p.m., 3 phase, 60 cycle, 125 volts	General Electric Co.
1	Turbo-generator	Curtis, d. c.	75 kw	Exciter for main turbines	3300 r.p.m., 200 lb. steam, 125 volts, 600 amp.	General Electric Co.
2	Pumps	Dry air	9x22x16-in	On condensers	Non-condensing, rotating	Wheeler Condenser & Eng. Co.
2	Condensers	Surface	7500 sq.ft. cooling surface	With main turbines	28-29-in. vacuum	Wheeler Condenser & Eng. Co.
2	Pumps	Centrifugal	16-in., 8,000 gal. per min	Circulating water for condensers	1000 r.p.m turbine driven	Wheeler Condenser & Eng. Co.
1	Pump	Centrifugal	10-in., 3000 gal.	Circulating water for condensers	1300 r.p.m. turbine driven	Wheeler Condenser & Eng. Co.
2	Turbines	Kerr	160 hp	Driving circulating pumps	1000 r.p.m., 200 lb. steam	Kerr Turbine Co.
1	Turbine	Kerr	60 hp	Driving circulating pump	1300 r.p.m., 200 lb. steam	Kerr Turbine Co.
2	Motor-generators	Synchronous, d. c g.	1075 hp., 750 kw.	Railway circuit	514 r.p.m., 514 volts, 3 phase, 60 cycle, d. c. gen., 600 volts	General Electric Co.
2	Pumps	Vertical	6x10x12-in	Pumping hot-well water	200 lb. steam	Warren Steam Pump Co.
1	Heater	Open	4000 hp	Heating feed water	Heating feed water to 200 deg	Pheonix Iron Co.
2	Boilers	B. & W	1000 hp	Steam generators	200 lb. steam, 125 deg. superheat	Babcock & Wilcox Co.
2	Boilers	Edge Moor	1000 hp	Steam generators	200 lb. steam, 125 deg. superheat	Edge Moor Iron Works.
4	Stokers	Murphy				Murphy Iron Works.
4	Superheaters	Foster		Superheating steam	125 deg	Power Specialty Co.
1	Crane	Traveling	5 ton	Handling coal	Motor operated, intermittent	Toledo Bridge & Crane Co.
1	Chimney	Concrete	215 ft. high, 12 ft. inside dia	Furnace gases	Natural draft	M. W. Kellogg Co.
4	Blowers	Vulcan		Boiler tubes	Steam at boiler pressure	Vulcan Soot Clesner Co.
1	Ref. System	Absorption	75 ton	Ice making	Exhaust steam	The Carbondsle Machine Co.
2	Pumps	Simplex	16x8x16	Aqua from receiver to generator	One held as reserve	The Carbondale Machine Co
1	Ejector	Duplex		Sump water	Intermittent	Yeomans Bros
1	Crane	Toledo	30 ton	Turbine room	Electrically	Toledo Bridge and Crane Co.

ing any larger than required for the electrical apparatus. The 16 and 8 by 16-in. aqua pumps are in duplicate and are under the platform supporting the generator.

Drainage from all the departments goes to a sump from which the water is handled by an electric sewage ejector. All high-pressure drips are piped to a receiver and the condensate is returned to the boilers. A 30-ton crane spans the turbine room and is electrically equipped.

⁂ ⁂

Will Quizz, Jr.

SYNOPSIS—The injector fails to work with the water-supply valve wide open. Will throttles the supply and gets it going, but does not know why it was necessary. He, as usual, asks Chief Teller.

⁂

"I put the injector on while I did some work on the feed pump last night, chief. I thought I was wise to all of its moods, but it did not act as it used to. The extra pressure on the water main seems to have something to do with it, because I had to close the water-supply valve part way before it would take hold. We used to run with it wide open. What is the reason?"

"The increased pressure, Will, gives the injector more work or water than it can handle. For example, a steam jet or nozzle of the same size acting on the rotor of a turbine, used to pump water into a boiler, will handle a certain amount of water and no more. The same is true of the jet in the injector. If you flood it with more water than can be given the necessary velocity, it will kick, of course. If the turbine drove a generator and you tried to draw amperes beyond its power, the voltage would drop as the speed reduced, but with the injector the speed, the velocity of the water, must be kept up to that necessary to equal or exceed the counter pressure and pipe friction.

"Suppose you had an ejector using steam at 10-lb. pressure at the jet with a length of pipe screwed into the discharge end, and a funnel in the side opening. If you introduced sand through the funnel in front of the jet it would partake of some of the velocity of the steam and be discharged from the pipe end. If, however, you increased the quantity of the sand and elevated the pipe end, you would soon reach the limit of the capacity of the jet and no sand would be discharged.

"Now, just what happened? In the first place, the sand, which had no motion, received or absorbed enough of the velocity of the steam to reach the end of the pipe against whatever resistance there was. Then as the amount of sand was increased and the elevation added, the velocity of the discharge diminished until the kinetic energy of the jet was all absorbed before the end of the pipe was reached.

"The whole operation would stop just as the injector stopped. If you could have reduced the resistance to the discharge from the injector, it would work with the inlet valve wide open, but since that could not be done and still feed the boiler from which the steam came, then, of course, the thing to do was to reduce the amount of supply. If it cannot handle the full amount, give it less weight of water. Why not? This also holds good when the steam pressure is down.

"Think of the water in the pipe as a long arrow, driven forward by the jet, which must have sufficient velocity to 'penetrate' into the boiler against the pressure and friction resistance. The pressure represents the feet elevation, and the weight of water handled the pounds, so that it becomes foot-pounds of work.

"By the way, the injector is one of the most efficient pieces of steam apparatus known. When considered as a boiler feeder and heater combined it is 100 per cent. efficient less the small loss by radiation, which goes to show that the whole case is not stated when it is said that it is not an economical boiler feeder. Of course, if there is exhaust going to waste, then using live steam to heat the water as well as to put it into the boiler by means of an injector is not the proper thing, but in many cases an exhaust-steam injector might be used. Look up the subject of exhaust injectors, which seems to be a paradox."

1200-Ton Chimney on Structural-Steel Support

By J. C. Lathrop

SYNOPSIS—A radial brick chimney, 250 ft. high, 25 ft. in diameter and weighing about 1200 tons, is erected and supported above the boilers on structural steel-work. The preliminary work was begun Apr. 23 and completed on June 12. The cost for all labor was $2117.25. Twenty carloads of chimney brick and three of firebrick were used.

⁂

The construction of a radial brick chimney on structural-steel supports at the Westport power station of the Consolidated Gas, Electric Light & Power Co., of Baltimore, has created considerable interest. This chimney will serve 12 water-tube boilers, each having a nominal rating of 1000 hp. and will probably be forced to 300 per cent. of rating at times. Six of these boilers are now on one side of the stack and the other six will be placed in an addition to the building which will be built adjacent to the side shown in Figs. 2 and 3.

A chimney with an internal diameter of about 20 ft., rising 250 ft. above the grates, was required, the stack to be supported upon a steel deck at the roof level so that the space in the boiler-room basement and main floor could be used for pumps and other auxiliaries.

Reason for Selection of Brick Chimney

It was at first thought that the most economical de-

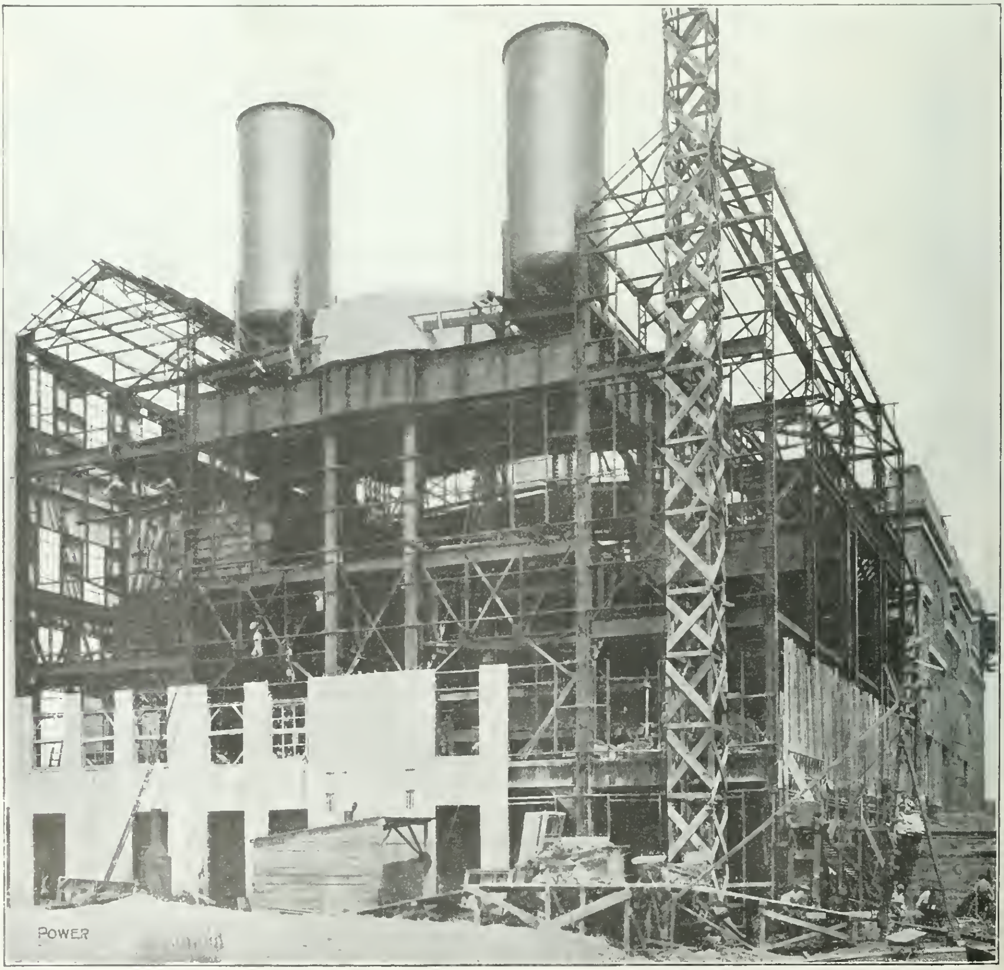


Fig. 1. April 27; about 7 Ft. of Chimney Completed. Note the Steel Supports

sign would be a brick-lined steel stack, carried upon the structural-steel work of the building. Such stacks are quite common in New York and other large cities and have given good service. There was doubt, however, as to the ultimate economy of this construction as compared with a radial brick chimney supported upon similar steel work. Therefore an estimate was prepared for each design based upon a minimum thickness of steel of ¼ in.

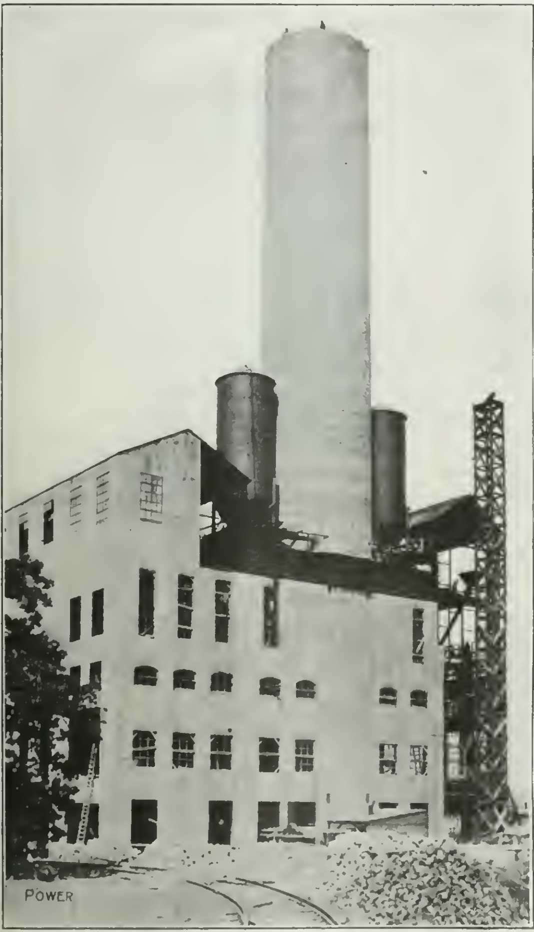


Fig. 2. Chimney about Half Completed

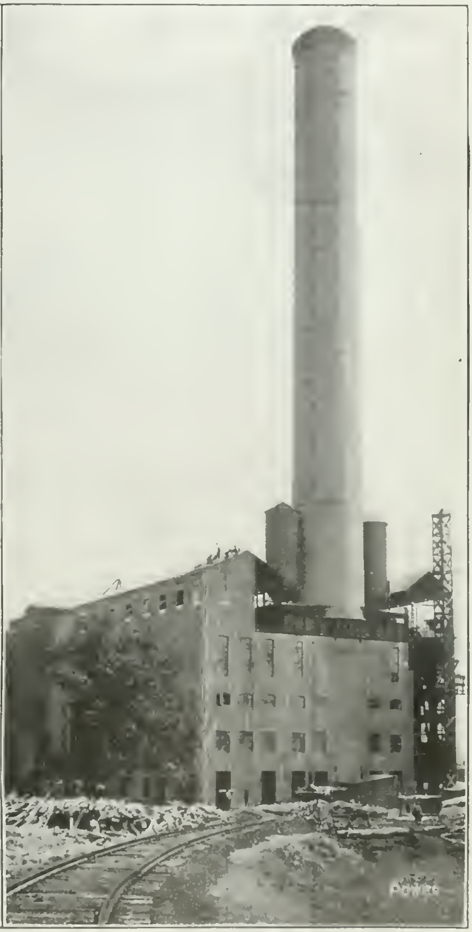


Fig. 3. Completed June 12

Although the comparative estimate was based upon a higher price for a radial brick chimney than was named in the final contract, the cost of the brick chimney, with the additional steel work, together with the foundation, piling, etc., was less than that for the steel stack with brick lining. Furthermore, it would not have been good policy to use metal as thin as ¼ in., even in the upper portion of a chimney of this size. It must also be remembered that the wind strains are about the same in either case, and while, with the brick construction, the foundations were designed for about double the total dead load on that account, they would need to be designed for more than twice the total load in the case of a steel stack. In addition, a brick chimney appears much more pleasing than a steel stack, and there is little doubt that the durability is much greater.

Structural-Steel Support

The base rests directly upon eight steel girders 72 in. deep, six resting upon the four interior columns, the other two framing into other girders which transmit a portion of the load to four additional columns. This construction is shown in Fig. 1. Horizontal wind bracing was so provided between these eight columns that the wind strains are carried to the foundation through the columns, although the direct weight of the stack is mainly supported by the four center columns.

The bracing, designed to carry the horizontal strains from the wind on the stack to the ground, also is shown in Fig. 1. The lattice girders also support a floor at the level 24 ft. 9 in. above the main boiler-room floor.

The four center columns are supported upon a single monolithic, reinforced-concrete foundation. The loads are transmitted to this foundation from the columns through a double system of grillage consisting of four 24-in. I-beams 8 ft. long under each column, these resting on a second layer of twenty-six 18-in. I-beams 21 ft. 8 in. long. The lower section of each column weighs 438.7 lb. per ft. and is composed of one 14-in. Bethelehem H-column, with two 18-in. plates each 2¾ in. thick.

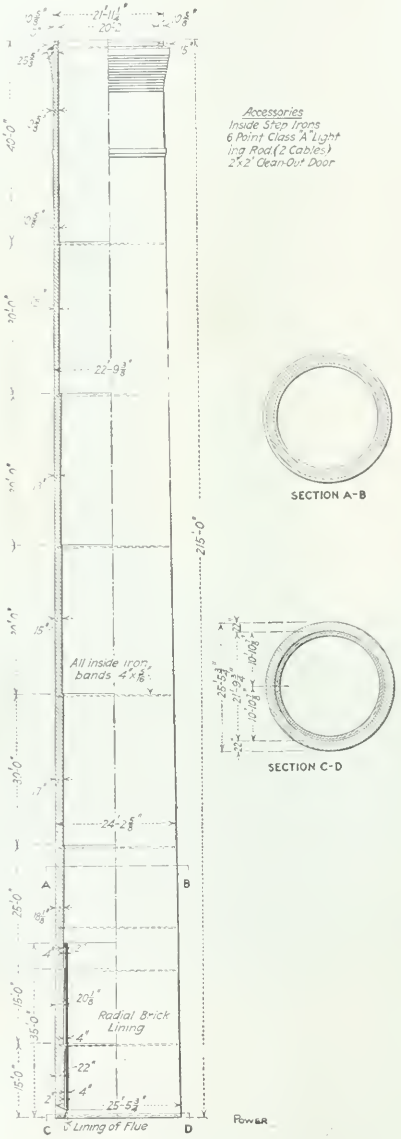


Fig. 4. Dimensions of Stack

The entire foundation is held by piles from 10 to 50 ft. in length. As these piles evidently rest upon the bank of an old stream filled with silt; it caused some apprehension until the chimney had been entirely completed and no settlement whatever was detected.

The chimney is 20 ft. 2 in. in diameter inside and rises to a height 215 ft. above the steel supporting girders; the outside diameter at the base is 28 ft. 5¾ in.; the complete stack weighs about 1200 tons; see Fig. 3.

The usual method of erection was adopted by the contractor, the Alphons Custodis Chimney Construction Co. A platform was raised as the work proceeded, the material being delivered to it in a tub raised by a hoisting engine.

Labor and Erection

The preliminary work was begun on Apr. 17 and it was completed about Apr. 23. Fig. 1 shows the condition of the work on Apr. 27, when 6 ft. of the chimney proper was finished. This portion was the most difficult, as several roof beams, etc., had to be put into place in the brick work. The photograph Fig. 2 shows the chimney a little more than half built, while Fig. 3 shows the stack as completed on June 12, 1914. The cement cap was put on June 3, and the final work of placing the firebrick lining, cleaning up and removing the machinery, etc., was done from June 4 to 12, eight weeks from the time this work was begun.

LABOR COST

Foreman, 40 days at $8	$320.00
Engineer, 40 days at $5	200.00
Bricklayers, 1303 hr. at 65c	846.95
Laborers, 3752 hr. at 20c	750.40
Total cost of erection	$2117.35

Date	Height completed	Date	Height completed
April 23	Preliminary work	May 19	125' 11"
April 24	Preliminary work	May 20	135' 5"
April 25	Preliminary work	May 21	144' 5"
April 26	Sunday	May 22	153' 5"
April 27	6' 0"	May 23	159' 4"
April 28	13' 5"	May 24	Sunday
April 29	17' 3"	May 25	169' 6"
April 30	Unloading cars	May 26	178' 6"
May 1	24' 1"	May 27	190' 0"
May 2	28' 7"	May 28	199' 0"
May 3	Sunday; unloading cars	May 29	204' 0"
May 4	36' 0"	May 30	No work; high wind
May 5	Rain	May 31	Sunday
May 6	42' 8"	June 1	212' 0"
May 7	48' 7"	June 2	215' 0"
May 8	54' 6"	June 3	Cement cap
May 9	58' 6"	June 4	Firebrick lining
May 10	Sunday	June 5	Firebrick lining
May 11	66' 6"	June 6	Firebrick lining
May 12	75' 3"	June 7	Sunday
May 13	83' 3"	June 8	Firebrick lining
May 14	93' 3"	June 9	Lowering scaffold
May 15	101' 9"	June 10	Cleaning up
May 16	106' 3"	June 11	Cleaning up
May 17	Sunday	June 12	Loading engine and tools
May 18	116' 3"		

Twenty carloads of chimney brick and two of firebrick were necessary. The labor used and the daily progress made are given in the accompanying table.

⁂

Ampère and His Work—André Marie Ampère was a distinguished French physicist and mathematician (1775 to 1836). His three most important contributions to knowledge were the following:

1. His clear analysis and mathematical description of the work of Oersted. It was in the fall of 1820 that Oersted discovered the effect of an electric current upon a magnetic needle. In less than a week after learning of this discovery Ampère had reduced the description to a mathematical formula.

2. The discovery that electric currents produced a magnetic effect upon each other; so that when the currents in two wires are flowing in parallel directions, they attract each other; but when flowing in opposite directions, repel each other.

3. The hypothesis that magnetic substances are made up of molecules in which electric currents circulate, but meet no resistance, these currents are therefore permanent. According to this view, a body is magnetized when its molecules are made to face more or less in one direction

Fedeler Dust Collector

The importance of an efficient dust collector cannot be overestimated, because with the ever-increasing amount of coal burned in boiler furnaces the floating dust not only becomes injurious to health, but its action is destructive. Dust has caused short-circuits between the electrical connections of switch and panel boards and poor oil has been blamed for hot bearings, when, as a matter of fact, sufficient precaution had not been taken to protect the bearings and engine room from dust. Gas engines in power houses are frequently injured by dust which enters with the gas and tends to ruin the valves and cylinders.

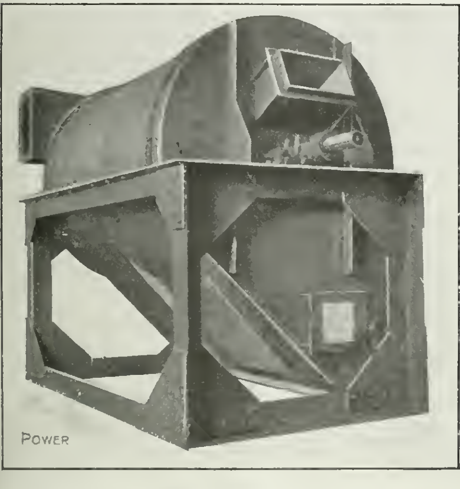


Fig. 1. Front and End View of the Fedeler Dust Collector

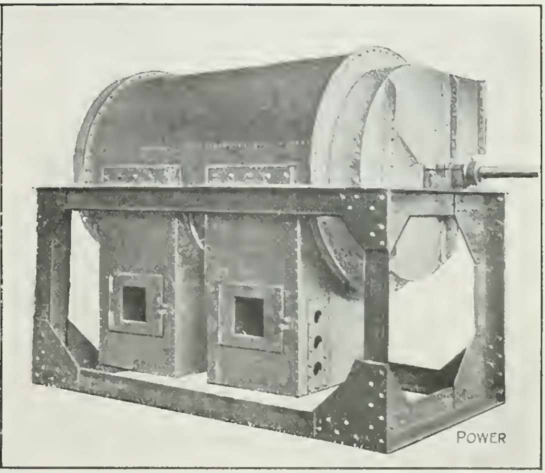


Fig. 2. Rear and Discharge End of the Dust Collector

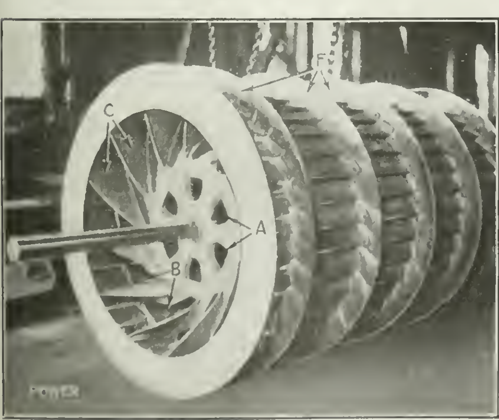


Fig. 3. Intake End of Revolving Drum

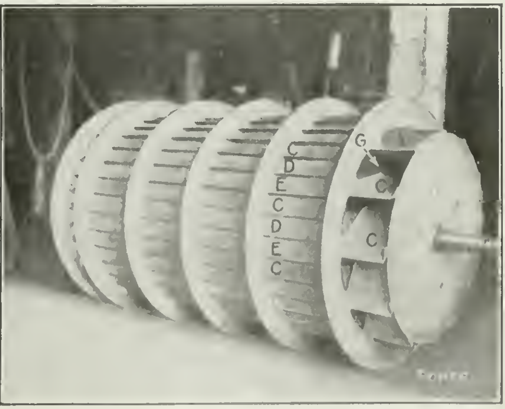


Fig. 4. Showing Designs of Baffle Plates

Dust is, as a rule, a particle of solid matter floating in moving air: when the air current is arrested the dust settles, and to move this particle a definite amount of energy is required. Therefore, the air always moves a little ahead and faster than the dust, and when the speed of the air is suddenly arrested, the dust keeps on going until the energy with which it was charged is expended.

In the dust collector here illustrated, the separation of dust from the air depends upon giving the air a sudden change of direction or speed. Office fans become dirty at the outer end of the blades, and as they give motion to the air, it would appear that the dust always lags behind the motion of the air.

The Fedeler blower and dust collector, Figs. 1 and 2, is manufactured by John H. Fedeler, 11 West Fortieth St., New York City. It is built with a drum containing a large number of fan blades which revolve in a casing, made with several compartments for collecting the dust. Holes are formed in the drum to allow the dust to be thrown out. As the heavier particles are thrown out first, the drum is divided into sections, so that the different weights of dust particles are drawn off separately.

Referring to Fig. 3, which shows the intake end of the revolving drum *A*, are holes used only in the construction and then covered. *B* shows the openings through which the air flows along a passage parallel with the shaft and formed by the tangentially arranged plates *C*, which are fastened to an inner, closed drum, to which the driving shaft is keyed. The outer edges of these air passages are protected by baffle-plates *D* and *E*, Fig. 4, the plates *C* being so bent as to throw the dust outwardly more readily. The separating rings *F*, Fig. 3, form, with the outer casing, separate compartments for the different grades of dust, but at the same time they project on the pressure side of the plates *C*, to form the pockets *G*, in which the dust is first caught and then thrown out of the revolving drum into the outer casing. As the pressure is above atmosphere inside the casing, the dust can be drawn off easily from this point in a concentrated form and easily removed.

Large machines work better than small ones, because with the increased diameter a corresponding increase in the length of the machine will allow a longer passage for the air. For example, air being delivered at one ounce pressure has a speed of about 80 ft. per second. A small machine of, say, 2 ft. in length would have to separate the dust, while the air was passing through the machine in one-fortieth second, whereas, exaggerating to make it clear, if the machine were 40 ft. long the air would stay in it one-half second. With an increased length and diameter, the number of passages also increase and, therefore, the capacity.

A separator of this type could be introduced between the boiler and the economizer and used to produce induced draft under the boilers, and at the same time clean the flue gases under pressure of perhaps several ounces of the economizers.

A further use of this type of machine is to ventilate engine rooms and at the same time provide a clean supply of air free from dust and maintain a higher pressure inside of the room, which prevents dust from being sucked in. The blower can also be used in supplying clean air for air-cooled transformers and for cooling turbo-generators.

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Boiler-Feed Piping*

SYNOPSIS—The functions of an internal feed pipe and how to arrange it for best results. The only advantage in feeding a boiler through the blowoff is that it helps to keep the pipe from becoming plugged. A circulating pipe may be connected with a valve outside of the setting that will do the same thing. Stresses due to local chilling are as great as 10,000 lb. per sq.in., which is too close to the elastic limit of the material.

※

INTERNAL FEED ARRANGEMENTS

The purpose of an internal feed pipe, or any internal feed device, is to raise the temperature of the entering feed as nearly as possible to that of the contents of the boiler before discharging it, and, secondly, to direct the flow of the discharged water so that it will assist and not retard the natural circulation due to convection currents in the boiler. In addition to discharging the feed in the direction of the natural circulation, it is also necessary to prevent the entering water from striking directly on the heated shell plates or tubes, and particularly must this be avoided at the joints. Careful choice of layout for an internal feeding device will modify the deposition of scale and sediment.

The feed introduced at the bottom of the boiler, colder than the water inside, is, of course, always denser than the boiler water; it cannot rise with the natural circulation until it becomes so heated that its diminished density makes it rise. It follows then that the feed must spread out on the lower part of the boiler surface, displacing the hotter and lighter water, until it has taken up enough heat from the metal to rise naturally. The metal is certain to become appreciably cooled by this enforced heating of cold water, because the rate of heat transfer from the hot metal to the cold water depends on the temperature difference, and will be greater the colder the water. The cooling is assisted because it takes more heat to raise the temperature of a pound of water one degree than is given up by the cooling of a pound of steel through a like temperature range. Moreover, since the heating is so rapid, by far the greater portion of the heat given to the cold feed must come from the store of heat already in the metal, and not from that being transferred through the metal from without. Therefore, a cooling of the boiler metal through a considerable range at each entrance of fresh, cool feed water is to be anticipated.

STRESSES IMPOSED BY COLD FEED WATER

It is well to consider the magnitude of the mechanical stresses involved when a boiler shell is locally cooled. Some years ago this subject was considered in *The Locomotive* (March, 1893), and calculations were made for the case of a steel boiler, working at 100 lb., into which feed water at 100 deg. F. was introduced. It was shown that under such conditions the plate would experience a drop in temperature of some 200 deg. F., and also that if the plate could be conceived of as being held rigidly at the edges by the unchilled portions of the boilers, stresses of 37,700 lb. per sq.in. might be developed in the chilled portions. This stress is great enough to seriously damage the plate, or even rupture the girth seams, but it is unlikely that so great a stress is produced, because the cooled portion of the plate is not held at its edges by an absolutely rigid structure, but is part of a shell which is elastic and yields under the pull of the cooled portion. Calculations which took account of this sort of action in the chilled boiler plate led to the conclusion that stresses of the order of 8000 to 10,000 lb. per sq.in. might be expected to occur in the particular boiler considered. This, of course, would be in addition to the pressure stress which a working boiler is always called upon to carry. A boiler plate, when stressed by the admission of cold feed water, must bear stresses quite too close to the elastic limit of the material for safety.

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*Abstract from an article in "The Locomotive."

The internal feed pipe for preventing these stresses consists of a length of piping near the water line and of such length that the feed may be heated in traversing it very nearly to the boiler temperature. The discharge end is so located, depending on the type of boiler, as to direct the water flow away from the joints and the shell, and, so far as possible, with the natural circulation.

The various forms of steam-space feed depend on breaking up the incoming water into a spray or thin sheet so as to expose a large surface to contact with the steam. The effect is to condense enough of the steam to raise the water to boiler temperature while falling to the surface of the water already in the boiler.

Design of Internal Feed Pipe

The design of an internal feed pipe must vary with the type of boiler. In the horizontal-return tubular the best practice is to carry the pipe through the front head at the side and just above the top row of tubes. The pipe then extends back toward the rear head for about two-thirds or perhaps three-fourths of the tube length, running parallel with the tubes. At this point its direction is changed through ninety deg. by an elbow, and the pipe is carried across the boiler to a point near the opposite side where it terminates in an open elbow, which is arranged to face down. The pipe should be rigidly supported by straps from the braces so that there can be no chance of its rubbing on the tubes or plate when it pulsates under the intermittent action of the pump. If there is rubbing, a very rapid corrosive action will occur at the point of contact. The cause, often wrongly attributed to friction alone, is to be found in the displacement of rust or scale at each pulsation of the feed pipe so that fresh metal is constantly exposed to the corrosive action of the boiler water, so that a rapid attack is to be expected even from waters not otherwise especially corrosive.

In a vertical tubular boiler the internal feed pipe is usually fitted to discharge just below the water line, near the center of the tube nest. This arrangement, while quite satisfactory, has caused trouble, in at least one case, from the repeated contraction and expansion of the tubes directly exposed to the impingement of the entering water. This may perhaps be due to the fact that in this type of vessel, it is not easy to arrange an internal pipe long enough to serve as efficiently as in the horizontal tubular boiler. However, with the feed heated to a reasonable degree by some of the many forms of feed-water heaters, no trouble need ordinarily be anticipated. In very small vertical boilers, it is usual to introduce the feed water at a point near the bottom of the water leg, although this practice is not to be commended.

In locomotive-type boilers, wherever the construction makes it possible, an internal feed pipe as described for horizontal tubular boilers should be used. When this is impossible, the feed should be introduced in the barrel as far from the firebox as is feasible.

Where feed pipes pass through boiler shells or heads, we have found the best construction to consist of a boiler bushing of either brass or steel, threaded tightly into the head or shell plate, and with an internal thread into which the outside part of the feed pipe may be screwed on the outer end while the internal pipe is screwed into the inner end.

Two general considerations should always receive attention before a layout for an internal feeding device is approved. First, it is imperative that the internal piping be so arranged as to remain full of water, for, should it become in part steam bound, water-hammer is to be expected when the water flow is again established.

Secondly, the piping should be placed to be readily accessible for cleaning and repair, as the internal portion of a feed line is subject to incrustation or choking from scale, and when partially filled with such a deposit, it may not be able to supply feed fast enough to meet the conditions of maximum steam demand without permitting the water level in the boiler to become dangerously low. A choked feed pipe is especially dangerous in a plant where it is the practice to feed fast enough to meet the conditions of maximum steam demand without permitting the water level in the boiler to become too low. A choked feed pipe is especially dangerous in a plant where it is the practice to feed the boilers as much as they will stand without priming, and then let the level gradually drop to the lowest safe limit on peak loads, so that the firemen will not have to feed water when called upon for the greatest flow of steam. Under these quite too common conditions, if the feed pipe is not free and the pumps in good order, trouble is likely to be had in getting the water line back to a safe point if for any reason the heavy load should last longer than usual, or if the fireman should be careless and let the water go too low before starting to feed again.

Of the material for internal feed pipes, brass is to be preferred. Brass pipe will outlast iron in boilers fed with pure soft water, carrying some organic matter, and will have a life at least as long as iron in most boilers. Even more important, perhaps, than durability is the great freedom of brass pipe from choking. This is because no rust scale forms, and there is great difficulty which ordinary scale matter seems to experience in attaching itself to this material.

Feeding through the Blowoff

One reason why the practice of feeding through the blowoff has persisted so long is that it protects the blowoff pipe. Where a large amount of scale is deposited by the feed water, there is a tendency for sediment and scale to form in the blowoff pipe, and when this sediment becomes hardened and attached to the metal, overheating follows, since the blowoff passes through about the hottest part of the boiler setting. When there is a constant flow of feed water through this pipe, the sediment is kept well stirred and has much less chance to settle and bake on with disastrous results.

It is easy to arrange a circulating pipe connecting the shell, just below the water line, with the blowoff pipe and on the boiler side of the blowoff valve, which will accomplish all that the feed water can do in the way of keeping the blowoff free, and at the same time permit of feeding the boiler in the safer manner through a proper internal feed pipe. The vertical part of the connection, since it is outside of the setting and not covered, will radiate heat to the atmosphere fast enough to cool the column of water contained in it. This cooled water, as it is denser than the boiler water according to the difference in their temperatures, will flow down into the blowoff pipe, to be again heated by the hot gases, and thus as it rises again to the boiler a flow will be established which will be rapid and will be maintained automatically as long as the boiler is under steam. A valve is fitted in this vertical pipe, near the tee where it joins the blowoff valve. This valve should be open at all times except when the boiler is being blown down, and it should be manipulated in a regular routine with the blowoff valves, so that the operator will acquire the habit of first closing the circulating valve.

In water-tube boilers, the same principles should be applied as in fire-tube boilers. The feed should not be introduced through mud drums or directly on the heating surface, but some form of internal feed pipe should be provided, adapted to the design of the boiler and which will be accessible, heat the feed water properly, direct its flow away from the heating surface and in line with the natural circulating current. This will usually be most easily accomplished by feeding in an upper or steam drum. Many excellent devices to do this have been designed by the builders of water-tube boilers, and many attempts have been made to combine with the feed-heating device some arrangement which will arrest and hold the sediment deposited by the entering feed when heated. They have only one objection; in the smaller drums usually associated with this type of boiler construction, it is rather difficult to so design an effective water-heating device which can at the same time act as a scale catcher, without seriously obstructing the spaces which must be visited by the inspector, and therefore rendering difficult the detection of incipient defects.

A single case exists where it is advisable to feed boilers through the blowoff connection. Where boilers are operated at low pressure for steam heating, and are fed with the condensed water returned from the radiating surface, then since the temperature differences are not great, both the circulation in the system and the return of the condensate will be facilitated by feeding through the blowoff.

* *

Motors, Their Principles and Uses—IV

By Gordon Fox

SYNOPSIS—Considerations affecting the selection of motor installations, including group versus individual drive, type of motor, speed characteristics and voltage.

*

In order to gain the advantages of motor drive it is necessary that careful consideration be given to all the factors affecting a proposed installation. A mediocre installation may entail the same first cost as a first-class one, yet may include inefficient and ineffective drives and will not accomplish the result most to be desired, namely, the attainment of better manufacturing conditions.

Individual vs. Group Drive

The first factor for consideration deals with the degree of subdivision of units of power. It is possible, although not always advisable, to furnish an individual motor for each driven machine. On the other hand, entire plants, departments or divisions thereof may be driven by single motors through the intermediary of mechanical transmission systems. Each method has its points of value.

Correctly applied electric power affects production in three ways, namely, quantity of production, quality of product and cost of production. These factors in order will be discussed with reference to their bearing upon the method of drive selected.

Motor drive can increase the quantity of production from a given equipment due to maintained speeds at the machines, better shop layouts and more reliable service. Too much emphasis cannot be laid upon the importance of driving machines in such a manner as to gain the greatest output therefrom even though this be done with attendant increased cost for driving equipment and greater consumption of power. A few figures based upon average conditions will serve to illustrate this point. Assume that a five-horsepower motor is used for driving a machine upon which two men are dependent. The various items of factory cost are as follows:

	Cost per Day
Cost of drive,	
Interest, depreciation and maintenance on motor. 12% per annum on first cost	$0.04
Cost of power,	
40% load factor,	
10-hr. day.	
2½c. per kw.-hr.	0.50
Cost of labor,	
Two men at $2.00 per day	4.00
Overhead cost,	
1½ times labor cost	6.00
Total cost per day for this machine	$10.54

It is evident that it would be good economy to double the cost of power or to increase the first cost of the drive many times over if in this way the output could be increased.

The falling off of production due to slippage losses is seldom appreciated. With shaft drives it is practically always found that there is a drop in speed of the machines under load, varying from 5 to 15 per cent. The amount of slippage depends upon the distance of the machines from the source of power, the number of intermediary countershafts, the ratio of pulley diameters, belt sizes and speeds and the condition of the belts. It is likely to be greatest for high-speed machines requiring the use of small pulleys and for very slow-speed machines requiring the use of low belt speeds. The relation of production to speed may or may not be in direct proportion. Where materials or tools are automatically or power fed, it is usually found that production is proportional to speed within certain limits.

Individual drive is well suited to that class of machines which require variation in speed. Such machines may be divided into three classes; those whose speed is under constant manual control, those requiring frequent adjustment and those operating comparatively long periods at given speeds. The first two classes may be independently driven most effectively; for machines of the third class, adjustable-speed motors may be provided, although constant-speed motors with mechanical speed-changing devices will sometimes suffice and may have lower first cost.

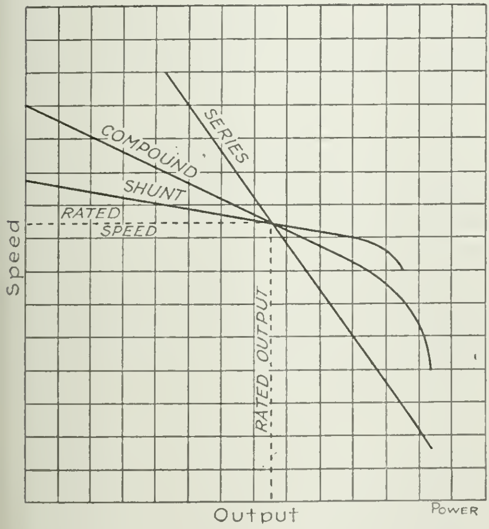
There are many hand-fed tools in which production is not increased directly with maintained speeds. Where the rate af handling material is the limiting feature the possibility of increasing production is lessened. In some cases the methods of handling can be improved so that the operating intervals are closer. It is true of most machines, however, that they perform their work more quickly at maximum speeds. This general statement follows: *Hand-fed machines, continuously operated, in which the productive processes consume a large percentage of the total time and the rates of performance of which are proportional to the speed should, in general, be individually driven.*

From the point of view of maintained speed only the following machines warrant group drive:

Small constant-speed machines, hand or power fed, which are too light to cause material slippage.

Machines intermittently operated, where the saving does not compensate for the extra cost.

Hand-fed machines where handling of the material must consume a large proportion of the time.



Speed-Output Curves for Direct-Current Motors

The second manner in which the method of drive affects production is in the shop layout. A close study should be made of the proper sequence of processes to reduce handling and machining of waste material and to gain the final result in the shortest total time. The product should be made to move as far as possible in one general direction. It is impossible to estimate the exact cost-decreasing value of a given layout but, in general, it may be stated that subdivision of power units should be carried out as far as there is any advantage whatsoever in the arrangement allowing better handling of material between tools. From the point of view of shop layout, *individual drive is usually warranted for heavy-duty machines.*

The third manner in which motor drive may be made to increase the quantity of product is through more reliable service. There are only a few machines that warrant the use of individual motors for this cause alone. It is frequently found that there are two or three machines through which the entire factory product passes or upon which whole departments rely for their material. For such machines individual drive is usually warranted.

The quality of the product may be bettered by motor drive, directly through uniform speeds and upkeep of machinery and indirectly through better manufacturing conditions. Direct-connected machines will remain in good condition longer than belted machines due to decreased bearing wear. Also subdivision of power units decreases the amount of overhead belting and shafting, allowing better illumination and ventilation.

While power costs are usually lower where individual motor drives are employed, it must be understood, however, that the substitution of a motor for some other source of power in a plant may not necessarily lower the power cost. A reduction in this item may be obtained by lowering the cost of generation or purchase, lessening the losses of transmission, and decreasing wasted consumption. The latter can be obtained only by applying the motors most effectively either individually or in small groups. Where individual drive requires the use of a number of very small motors, the lower efficiencies may counteract the advantage of subdivision. Also machines widely scattered usually incur large transmission losses, and where the length of shafting per horsepower used is large the losses will be heavy.

The great difference between mechanical drive and individual motor drive in the matter of power consumption is that the losses with motor drive are roughly proportional to the load delivered whereas with mechanical drive there is a fairly constant loss regardless of the load. In view of this, if the cost of power is a considerable item, the use of small power units may be justified. Moreover, independent motors should be installed for driving such machines as will be required to operate overtime.

Regarding overhead cost, the point is often raised that it is necessary to install a greater total horsepower in motors for individual than for group drive. This is generally true but in a modified degree. Motors driving groups must not only be of sufficient capacity to meet the power demand of the machines but must supply transmission losses also. This contention depends largely upon the diversity factor. If the ratio of average load to connected demand is low the group motor may be relatively small. This feature plays an important part in determining comparative first costs. A number of intermittently operating machines which are not simultaneously used can be group driven with low first cost and good efficiency. A related condition exists where machines require heavy instantaneous peaks or starting loads. Individual motors must necessarily be of sufficient size to carry these overloads. If such machines are grouped, the peaks are smaller in proportion to the capacity of the single-group motor. This motor may then be much smaller than the connected capacity with individual drive.

In some cases the driven machines may form natural groups where several interdependent operations are performed on machines closely related. For instance, the operation of a brick machine requires simultaneous driving of conveyors and cutting table. Groups of this character are often best considered as a unit.

In summarizing, it may be stated that individual drives are best suited for machines continuously operated whose production is directly or largely dependent upon maintained speed, for adjustable-speed work where ready control is desirable, for most heavy machinery, and where necessary for most effective location. Group drive is best suited to natural groups, for driving numbers of light machines, for driving machines intermittently operated and not simultaneously used and wherever the advantages of individual drive are insufficient to warrant the extra cost.

Types of Motors

The relative value of alternating and direct current for industrial power service is a matter receiving considerable discussion. The inevitable conclusion remains that each system has specific points of superiority adapting it to particular fields. There are several types of alternating-current motors having a fair range of characteristics; yet there are several types of direct-current motors affording another possibly wider variety of characteristics. Certain results can be paralleled in either class; other results can be attained in one class only.

Where power is purchased the type of motor installed is usually dictated by the current available, although this is not always warranted. The use of a motor-generator set for conversion may incur a greater first cost and a slight loss of power. The cost of power, however, is often only a small percentage of the total factory cost, and if manufacturing efficiency can be better secured with a given type of motor that type should be installed. The economies obtained will ordinarily more than repay the slight increased cost for equipment or power.

The advantage of the alternating-current induction motor is simplicity; its great disadvantage is inflexibility of speed. It is essentially a constant-speed machine having a few fixed speeds and as the majority of drives require constant speed the field for this motor is large. For this service its reliability, low maintenance cost and general ruggedness are strong recommendations. The first cost is lower than that of the direct-current motor, although the cost for wiring is somewhat greater; its efficiency is comparable with that of the direct-current motor except for the lower speeds, and it is lighter. It has no commutator and usually no brushes, and has good starting torque which is accompanied, however, with a rather heavy rush of current. Its pull out or stalling torque is liberal and it does not succumb to the effects of overloads as quickly as does the direct-current motor. Its characteristics parallel closely those of the direct-current shunt motor and it can be adapted successfully to most applications for which that type is suited. A disadvantage peculiar to the induction motor is low power factor under fractional loads requiring liberal provisions in generating equipment.

Induction motors may be used for certain classes of variable-speed work; this range is limited, however. The multispeed motor affords three or four rather widely separated running speeds without intermediate control. The slip-ring motor permits of graded control over a limited range only. It parallels the direct-current motor with armature control having a fluctuating speed dependent upon the load. This fact makes it unsuited for machine-tool work. It finds some application for blowers, pumps, printing presses and the like where the torque is fairly uniform.

The synchronous alternating-current motor has few advantages for industrial service from the point of view of the driven machine. It has low starting torque, constant speed over its entire range, a high first cost, requires an exciter and usually a switch panel and demands intelligent attention. Its use is justified, largely because of electrical considerations, as a synchronous condenser to counteract the power factor effects of a number of partly loaded induction motors.

Single-phase motors are largely confined to small sizes upon central-station circuits for minor installations. They are seldom used extensively in industrial service.

The direct-current simple shunt motor is a constant-speed machine. It exerts a fair starting torque and moderate overload torque. The compound-wound motor has a less constant speed but can exert a heavy starting torque with low current input and has a liberal overload capacity. Its performance can be approached but not duplicated by the induction motor with high rotor resistance. The series motor exerts heavy starting and overload torques and its speed varies widely with the load. Its performance cannot be duplicated by the induction motor. Shunt or compound-wound motors may have their speeds externally controlled over a wide range, the speed remaining approximately constant at any point. This result cannot be attained by any type of alternating-current motor.

The advantages of direct-current motors are: flexibility and freedom from limitation in speed, wide range of torque characteristics, ease of speed control, simplicity of wiring and control devices, adaptability to remote control, quick acceleration, low starting current, wide air gap, freedom from power factor effects and ease of dynamic braking. The great disadvantage lies in the presence of a commutator and brushes, decreasing reliability and ruggedness and increasing maintenance costs. In general, it may be stated that the direct-current motor is superior in electrical characteristics and the induction motor in mechanical features.

Choice of Voltage

Where direct current is used, 220-volt service is nearly always suitable and is almost standard. The use of 550 volts may be necessary due to local considerations such as for car shops, etc., but its general use is to be discouraged due to increased maintenance expense. The use of 110 volts requires considerable expenditure in copper for the wiring system with little gain in reliability. Illumination requirements may occasionally dictate its use.

For alternating-current work 220 and 440 volts are the most common, the latter being preferable where large motors are used due to decreased cost of wiring. At present, 2200-volt motors are not extensively used in factories due to increased risk, higher first cost of the motors and wiring and somewhat greater liability to trouble.

The choice of frequency is generally of less importance. Sixty-cycle motors allow higher speeds and a greater choice, which may be a distinct advantage in some cases. On the other hand, 25-cycle motors can be obtained for slow speeds with better power factors. Sixty-cycle motors are lighter in weight and lower in first cost. Twenty-five-cycle current is not satisfactory for illumination with arc lamps.

There is little advantage in the three-phase system over the two-phase system although three-phase motors show slightly higher efficiency and the cost of wiring is lower.

Following are some items which should receive consideration when deciding upon the details of any motor installation:

Running speed and torque characteristics.

Is the load steady or fluctuating? What is the cycle of changes?

Is the load continuous or intermittent?

Is constant torque or constant horsepower required?

What starting torque is required? Is it the same for all positions?

Is frequent starting necessary?

What are the limiting features of the load?

Can the motor best be direct connected, belted, geared or chain driven?

Is the motor near a source of heat or subject to dirt, iron chips, injurious fumes, gases or moisture?

What fire and explosion risks occur?

What is the intelligence of the operators?

Is the motor to be in position for good ventilation and accessible for repairs?

What is the best method of control and most convenient location of control equipment?

Should fuses, overload release or time-limit devices be used for protection?

What will be the effect upon the source of power?

Size of Motor

The size of motor selected for a given work depends upon the average load, the maximum load and the starting requirements. The horsepower ratings of motors are based upon temperature rise. A 10-hp. motor is not limited to a 10-hp. load. It might deliver 20 hp. for very short periods, if during other periods it delivers less than 10 hp. In the majority of cases, the motor size should be determined by the average load, not the maximum. Particularly in alternating-current work it is undesirable to install larger motors than necessary, as they operate at lower efficiency and power factor on partial loads.

The starting torque of a machine may be determined by mechanical measurement, a rope being attached to the belt or passed around the driving wheel, and sufficient pull exerted to start the machine in motion; this pull is measured by means of a spring dynamometer. The radius of the wheel being known, the torque in foot-pounds may be directly calculated. If preferable, a lever may be attached to the driven wheel and weights added at a given radius until the machine is started. The torque may be estimated from this data, including the weight of the lever at its middle point.

The relations of load, torque and speed should be considered in determining the type of motor best adapted to a given work. The accompanying curves show the relative load-speed characteristics of shunt, series and compound-wound motors. The speed of a series motor is shown to be excessive when running under no load, but falls off rapidly as the load is increased. The shunt motor, on the other hand, has a no-load speed not much greater than that at full load, the decrease in speed being comparatively slight with increase of load. Again, the compound-wound motor is seen to have a characteristic lying between those of the shunt and series motors. Consideration of these curves will show that the shunt motor is adapted to driving machines which require a starting torque not greatly in excess of full-load torque and requiring practically constant speed. The series motor evidently will have an advantage where high starting torque is required and speed variation is not an important factor, or where the character of the load prevents excessive speed variation. The compound-wound motor will meet the requirements more specifically where the starting demand is greater than that which can be met by the shunt motor and where at the same time it is desirable to maintain fairly constant speed over a considerable range of load.

The squirrel-cage induction motor is generally used for work similar to that for which the shunt-wound direct-current motor is fitted. The squirrel-cage motor with high resistance rotor approaches in characteristics the compound-wound motor. The slip-ring motor is similar to the compound motor with a large percentage of compounding. This is the nearest approach obtainable to the direct-current series motor.

Special care is required in selecting series motors because their speed varies widely with the load. In order to provide for a definite running speed, it is necessary that the exact load be known. A series motor is rated at its full load speed, and if the load be greater or less, the speed will be lower or higher, respectively. Series motors are not generally suited for belt drives, since if the belt should be removed the motor would race and might destroy itself. They should be positively connected to the driven machine through couplings, chains or gears.

Adjustable speed requirements cover a varied set of conditions not easily differentiated. The more common types of variable-speed service and the usual methods of driving them may best be shown in tabulated form.

In direct-connected applications, the speed of the motor is closely fixed; for gear and chain drives there is often some choice. In such cases, the motor speeds should be as high as good mechanical conditions permit due to lower first cost, and, for induction motors, better efficiency For belt drives, there is usually considerable range for selection in motor speeds. High-speed motors often necessitate small pulleys and wide belts. It is well to figure the total cost of two or three possible arrangements, including the cost of motor, belt and pulleys. If there is no choice from a mechanical standpoint, that arrangement having the lowest first cost should be selected. In this connection, the relation of belt speed to cost of belt maintenance should not be overlooked. Other things being equal, the preference should be given to high-speed induction motors and moderate-speed direct-current motors. An attempt should be made to restrict the number of different ratings where this can be done without sacrificing the drive. There is considerable advantage in duplication of machines due to interchangeability and ease with which repair parts may be provided.

Aside from speed and torque considerations, efficiency and power factor should receive attention. It is false economy to install an inefficient motor because of slightly lower first cost, and to lose in operating costs many times the margin saved. The importance of this depends, of course, upon the unit cost of power and the motor load factors. It must be remembered, however, that the bill for a motor is paid once, that for power many times over.

The effect of low power factor is to cause increased losses in distribution and equipment, and to affect the voltage regulation of transformers and generating apparatus. Its importance to the user is greater where isolated plants are installed. If a number of small motors, operating on partial loads, are connected to the lines, difficulty may be experienced in maintaining the voltage and liberal generator and exciter capacity is required. Tirrill regulators are useful in this connection, but cannot entirely overcome the difficulties.

Mechanical Considerations

Some of the mechanical considerations affecting motor selection may be briefly enumerated. Weight alone is not a good basis for comparison, as some motors contain large amounts of inactive material. General dimensions and workmanship throughout are the best indications. The design should permit accessibility and provide for free ventilation and radiation. The frame should be rigid, with low center of gravity and widespread feet. The bearing flanges should allow access to the interior, should shield the windings and should form rigid bearing supports. The bearings should be liberal. Phosphor bronze is not desirable for large sizes, due to its tendency to freeze tight when heated, causing possible injury to the shaft. A liberal air gap is desirable in direct-current motors for electrical as well as mechanical reasons. A wide air gap in induction motors is usually accompanied by low power factors. A reasonable clearance is desirable, with provision for taking up wear in the larger sizes where wear is more rapid. Heavy shafts are advantageous for maintaining alignment and withstanding strains, and for distributing bearing wear. Insulating methods are of great importance, and measurements of dielectric strength and insulation resistance are useful.

The quality and finish of accessories, such as control equipment and base or rails, should bear consideration. However, it is better to simply specify performance and to consider the details of the equipment proposed rather than to try to bind the manufacturers to specifications which will likely conflict with their standard methods.

SOME MOTOR APPLICATIONS

Class of Service	Typical Example	Type of Motor and Method of Control Direct Current	Alternating Curreot
Wide range of operating speeds to be approximately constaot at any point.	Machine Tools.	Shunt interpole motor with field control.	Not attainable electrically. Use mechanical change devices. Multispeed motors for special cases usually of coostant-horsepower type.
Moderate speed range. Decreased speeds corresponding to decreased loads. Uniform torque.	Fans, Blowers, Pumps.	Shunt or compound motor. Armature control, or combined field and armature coptrol.	Slip-ring motor with suitable external resistance.
Small range of operating speeds near oormal. Decreased speed for short intervals.	Printing Presses.	Shunt or compound motor with combined field and armature control.	Slip-ring motor with suitable external resistance. Multispeed motors in special cases, usually of constant-torque type
Continuous manual control.	Elevators, Cranes, Hoists.	Compound or series motor. Armature control.	Slip-ring motor with suitable external resistance.

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Chain-Grate Settings--I*

By Osborn Monnett†

SYNOPSIS—Horizontal vs. vertical baffles for water-tube boilers, and a comparison of flat and sprung arches.

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In taking up the application of mechanical stokers to water-tube boilers, one of the most important types and alphabetically first is the chain grate. When properly installed, it is an excellent stoker for smoke suppression. There is no cleaning period which is the bugaboo of a great many mechanical stokers, and in other respects the human element is reduced to a minimum.

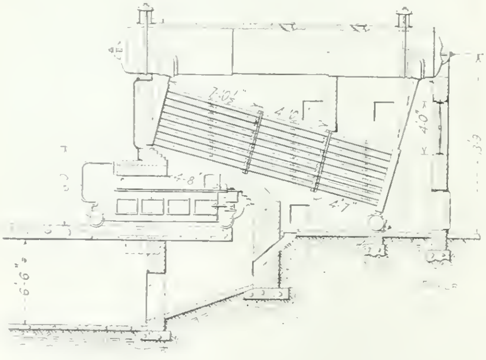

FIG. 1. OLD TYPE CHAIN-GRATE SETTING

The first question naturally arising is the choice of baffling. There is a great deal to be said on this subject, but in general it may be stated that the horizontal baffle is much safer from the smoke standpoint. Elaborate tests have been made to determine the effect of horizontal baffles on the capacity and efficiency of a boiler, as many engineers are prejudiced against the horizontal baffle on account of the fear that there will be a falling off in one or the other of these items.

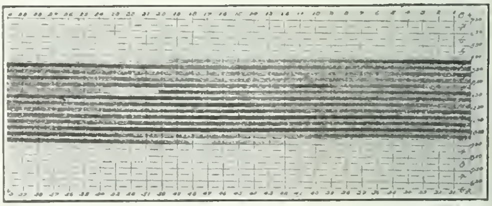

FIG. 2. SMOKE CHART OF SETTING SHOWN IN FIG. 1

A striking illustration of the effect on smoke production with a 350-hp. horizontally baffled boiler and the same boiler vertically baffled can be seen in Figs. 1 to 4. Fig. 1 shows the boiler with the old-style chain-grate setting, with a head room of 6 ft. under the front header. Fig. 2 shows the smoke performance of the setting. The boiler was then raised 2 ft., giving 8 ft. under the front header, and horizontal baffles giving a single pass for the gases were put in, Fig. 3. The smoke record after the change is shown in Fig. 4. The original installation gave an evaporation at 212 deg. of 6.05 lb. of water per pound of coal as fired. After the change, the evaporation was 5.96 lb. of water. In both tests, coal of 8902 B.t.u. per lb. as fired was burned.

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†Smoke inspector, city of Chicago.

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From test data available, it can be definitely stated that the difference in efficiency between well set vertically baffled and horizontally baffled boilers working within commercial limits and with both boilers in equally good condition inside and out, is negligible. It is usual to realize an efficiency of 65 to 68 per cent. with either type of baffling under good operating conditions when using a low-grade Illinois screening.

Working under normal capacities, the horizontally baffled boiler does not suffer appreciably over the vertically baffled boiler. When driven to capacities up to 175 per cent. of rating, the single-deck horizontally baffled boiler will show a dropping off in capacity of 10 or 12 per cent. over the other type of setting. For the ordinary industrial boiler plant, the difference in either capacity or efficiency can be neglected where the boiler is not run at a rating higher than 50 per cent. overload.

There are other points to be considered, however, before deciding on the gas passes. It must be admitted that the horizontal baffle on boilers having the B. & W. tube spacing costs more to install, costs more for maintenance, and, owing to the tendency for pockets of soot to form on the baffles, must be watched more closely in operation to obtain capacity and efficiency. The character of the attendance then is a feature, and the draft loss through the setting is generally greater.

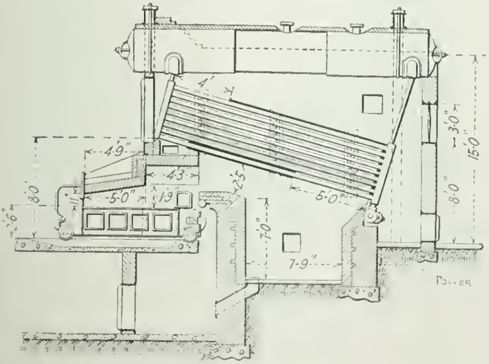


FIG. 3. IMPROVED SETTING FOR SAME BOILER

The selection of a horizontally baffled boiler may be made through limited head room or where the smoke question is of prime importance. There are certain industries where horizontally baffled water-tube boilers will produce less smoke, as in connection with a chain-grate stoker it is about as "foolproof" as anything that can be designed to run smokelessly. It is an ideal equipment for a plant where labor conditions are liable to be a factor; where many changes are made in the operating force, or where there is a strong probability of unskilled attendants. Also, such an installation is ideal for a steel works, a packing house, railroad shop or any industry where men work on 12-hr. shifts. With so long a watch, carelessness is apt to creep into their work. On the other hand, if accumulations of soot are allowed to collect on the heating surface, then this type of setting will not compare favorably with a vertically baffled boiler.

Another question arising with chain grates is the choice of flat or sprung arches. Many engineers will not put in a flat arch owing to the fact that in the past they have been installed improperly for the work they were designed to do. With the sprung arch, the cubical contents over the fire is greater. For this reason, the gases are not restricted and pass away rapidly from the furnace. The ordinary sprung arch is generally set level, with the skew-backs about 9 in. above the grate, and the highest point of the spring 18 in.

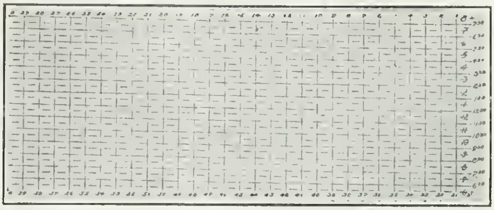


FIG. 4. SMOKE CHART FROM SETTING SHOWN IN FIG. 3

On the other hand, the flat arch is somewhat cheaper to install, cheaper to maintain, puts less stress on the side walls, and in many ways has constructional advantages over the sprung arch. The latter must be taken out of service immediately when it commences to deteriorate, owing to the danger of complete and sudden failure, whereas a flat arch, with each element suspended independently, can run along indefinitely until it is convenient to take the boiler out of service. The ordinary flat arch of a few years ago was set too low at the gate and was too short for high capacities. The practice was to set the arch 11 in. above the grate at the gate and about 22 in. at the inner end, with a length of about 3½ or 4 ft. This was not enough arch to give a good igniting effect; the clearance between the arch and the fuel at the gate was too small to take care of the thick fires and heavy overloads sometimes encountered.

When installing flat arches, it is now common to raise them higher above the grate to give a generous volume into which the volatile matter may expand. Their length has also been increased. The minimum length of arch for any chain grate should be not less than 5 ft., and wherever necessary to get the proper furnace design it may be longer. This has resulted in a substantial increase in the capacity of furnaces equipped with flat arches.

Temporary Rheostat Repairs

It frequently happens that starting or field-control rheostats become open-circuited, due to the burning out of a coil at a time when it is impracticable to remove them from the circuit for repairing.

In these emergency cases a temporary repair can be made by ringing out the rheostat (button by button) with a magneto until the break is found, and then filling the gap between the two buttons at the break with solder, filing the surface off flush with the contact buttons.

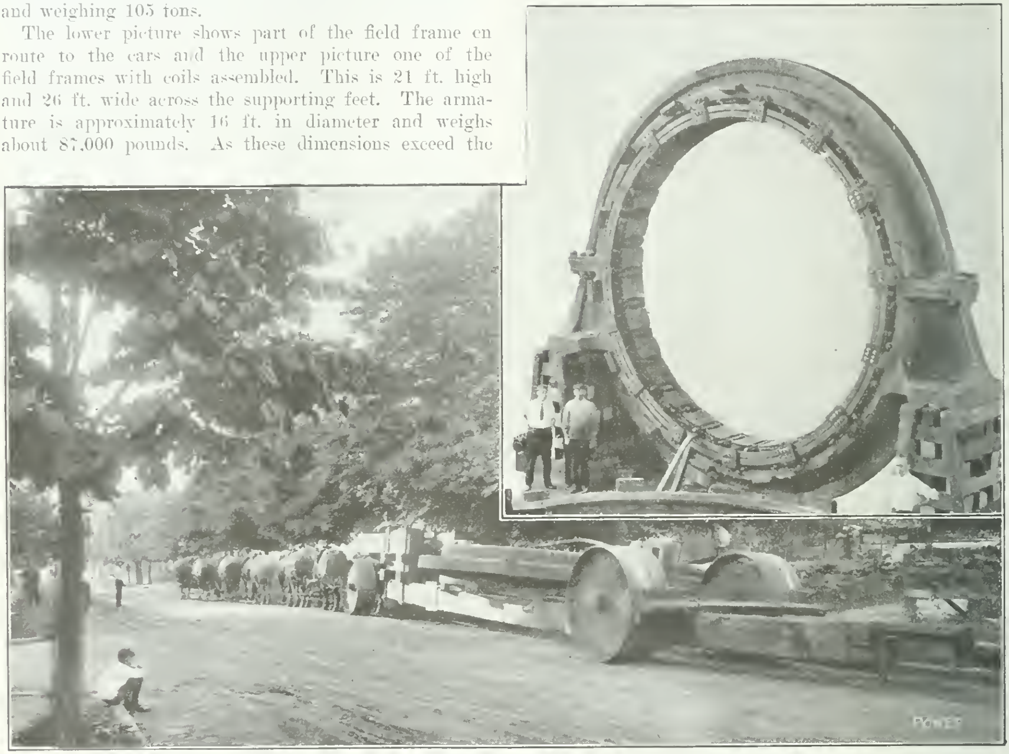
As to starting rheostats, cutting out the defective coil may make the starting a little uneven, and because of this the rheostat arm should be brought up somewhat slower than ordinarily. The only effect on the operation of field-control rheostats is slight resistance decrease.

In cases of extreme emergency, it is possible to keep a defective rheostat in service for some time by wedging a piece of fuse wire or forcing a nail in the gap between the defective contact buttons.

Handling of Large Direct-Current Generators

The first car containing generator parts for the mammoth direct-current power plant of the Ford Motor Co. recently left the works of the Crocker-Wheeler Co. at Ampere, N. J. It will require about fifteen cars to transport all the material which comprises these four big units, each one having a normal capacity of 3750 kw. and weighing 105 tons.

The lower picture shows part of the field frame en route to the cars and the upper picture one of the field frames with coils assembled. This is 21 ft. high and 26 ft. wide across the supporting feet. The armature is approximately 16 ft. in diameter and weighs about 87,000 pounds. As these dimensions exceed the limits set by the railroads for clearances on tracks, bridges and tunnels, the assembly of the armature parts and winding will be done in Detroit.



Upper View: Stator with Field Coils in Place. Lower View: Part of Stator Being Transported from Shops

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Some Alaska Boilers Described

By Edward M. Keys, Jr.

Being in need of a small boiler at the mine here in Alaska, I searched the country for a second-hand one. I found many in a dangerous condition and naturally did not make friends by saying so.

One 10-hp. upright had been allowed to fill with mud around the side of the firebox, and became overheated and bulged between the stays until the metal was only a scant ⅛ in. thick. Mud had also collected on the lower tube sheet and pockets had formed. The owner stated that it had carried 180-lb. pressure without exploding, and he knew it was safe!

A machinery firm had one for sale which did not look good, and the manager, when it was suggested that he knew very well that the boiler would never stand marine inspection, replied, "In marine work they cannot afford to take chances."

The next examined was a locomotive-type boiler, but one peep at the crown sheet was enough.

At another place a man was just firing up a little upright, and while asking him a few questions regarding any boilers of which he might know, I noticed that he started the injector with no pressure registering on the steam gage. I asked him if the gage was not out of adjustment. "Oh, she's only got 60 lb. of blind steam," he replied, and explained that he meant by "blind steam," the pressure not recorded by the gage.

At another place a 60-hp. boiler had only a 1-in. pop safety valve and that had a stop valve between it and the boiler.

A boilermaker, taking the tubes out of a 40-hp. return-tubular boiler, told me to look inside. Mud had accumulated on the tubes, and was packed solid between them in some places. The crown-sheet had an inch of mud on it. Two new handholes had to be cut in the sides to get the mud out of the water legs and the sheets had nearly pulled off the stay-bolts.

Surely, we need an inspection law here, where boilers of from five to three hundred horsepower are being operated by inexperienced men.

Editorials

Detecting Lap Cracks

One of the principal causes of disastrous boiler explosions is the lap-seam crack. Considering the present agitation for "safety first" and the evident demand for laws to govern the construction and operation of steam boilers, with the idea of reducing the loss of life and the destruction of property occasioned by boiler explosions, it would seem logical for the law makers to take some surer means to eliminate this cause.

True, practically all modern boiler laws recognize the danger in this form of construction and prohibit its use in new boilers; while such laws will ultimately do away with lap-seam boilers, it is not practical to require owners of lap-seam boilers to discard them for more modern construction. While the butt-strapped construction is more widely used today than a few years ago, there are, no doubt, several times as many lap-seam boilers constructed now as there are butted and strapped type. These boilers must be operated for years yet, and while the laws in force have tried to curtail their use, by prescribing high factors of safety, this remedy is little better than condemning them outright.

Another objection to increasing the factor of safety is, that it has never been conclusively demonstrated that the factor of safety has had any bearing on the subject, for boilers that have been operating at very moderate pressure seem to explode as readily from this cause as those operating at higher pressures. The difficulty has been that the lap-seam crack defies detection until it has weakened the structure so much that an explosion is almost inevitable. A number of ways have been suggested for detecting these defects, such as testing the electrical resistance of the plate across the part that was supposed to be affected, and taking X-ray pictures, with apparatus strong enough to show the cracks in the plate if they should exist, but none of these seemed to be practical and were never tried. Recently a process has been proposed for this purpose, that is so simple that it would seem impossible for it to fail to detect such cracks if they exist in a boiler to which it is applied. This method was explained in the July 11 issue of POWER, on page 56.

Since lap-seam boilers cannot well be exterminated at once, it would seem proper for the law makers to require that all owners of them provide this simple means of determining whether they are sound or not.

After a recent explosion produced by a lap crack, the mating boiler, of the same make and age, was suspected of having the same defect, although no external evidence revealed it. Cutting the seams as described in the article referred to above, showed the presence of dangerous cracks and use of the boiler was abandoned. If this test had not been applied, likely this boiler would have been placed in service and it might have later exploded and caused as much loss of life and destruction of property, as did its mate.

In another instance two boilers were suspected of containing lap cracks, because the mating boilers of the battery had developed such cracks several years before which fortunately were discovered before they resulted in an explosion. The inspector was disturbed about these boilers and had told the owners of his fears, but had to admit that his apprehensions were grounded on conjecture only and that he had no positive knowledge that there was anything the matter with the boilers. However, when the detector slots were placed on the seams, it was conclusively shown that very dangerous cracks existed in the plate and use of the boilers was discontinued at once. In numerous other instances this test has shown that suspected boilers were perfectly sound and could be safely continued in use so far as danger of an explosion from a lap crack was concerned.

It is proposed by some to discard lap-seam boilers after a given number of years' service, but this would be an uncertain remedy, for explosions from this cause have been known to occur with boilers only three years old, while others are twenty years old before showing the same defects. Usually lap-seam cracks appear in from ten to fifteen years. The method of detecting the lap-seam crack, here referred to, is practically the same principle as the drilling of the ends of staybolts to determine when they break. If as many explosions resulted from the breaking of staybolts, as from the formation of the lap crack, there is little doubt but that the drilling of the ends of the bolts to detect such defects would be compulsory.

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Oil-Engine Outlook

Probably the only important factors now to limit the growth of the internal-combustion industry in America, particularly the oil engine, are the cost of the fuel employed, capacity feasible in a single unit and human conservatism. Due to the better knowledge and greater experience of the manufacturers, the foundation for the old prejudice against this form of prime mover because of its unreliability has been largely swept away. The hackneyed charge that America could not produce the class of workmanship found in Europe is now refuted in this and other fields. The manufacturers have been brought to the realization, when not so possessed at the outset, that not only must suitable material and high-grade workmanship be alleged but must actually be employed.

In the general power field, producer-gas installations and heavy oil engines must compete with steam-driven prime movers and with each other. In some cases geographical location may clearly require or local conditions may indicate a given type, but in general, operating costs and personal preference will govern the selection. A few years ago the gas-producer plant seemed to be the "runner up" of the small steam installation from the standpoint of economy, but the oil engine seems now to have supplanted it in the contest.

It is often hard to overcome the hesitancy of man to try the untried, notwithstanding the weight of reason, even in his own mind, may be against his attitude. This is indicated by the fact that there are people doing business who have not adopted the typewriter or the telephone, although they know, or should know, that to do so would be to their advantage.

The basic Diesel patents having lapsed, the heavy-oil-engine industry has received an impetus by the entrance into the field of many well established and equipped concerns, which presages progress in this line.

He Weighted the Safety Valve

The safety valve on a boiler at the Thornhill Iron & Steel Works, at Dewsbury, England, persisted in blowing. Thinking that this was due to the valve not being tight, the engineer of the works instructed an attendant to hang a weight on the lever. He thereupon put on a fifty-pound weight. This failing to stop the escape of steam, the engineer instructed him to put on another, which he did, this time of over sixty pounds with about ten pounds of hooks, etc., whereupon the boiler exploded, causing the death of seven men and serious injuries to over twenty others. There are lots of men in charge of boilers who do not know any better. Is it time for an inspection and license law?

Reading in the Engine Room

One says that the engine room is no place to read; another that a good engineer will find something else to do rather than read. Numerous similar objections may be made to the practice. While we are not arguing that the engine room should be made a reading room, we can see no reason why a good engineer should be constantly on his feet or tinkering with something or other. Then, if he has a place where he can keep his eye on everything, certainly there is no harm in his sitting down and reading.

This applies particularly to the night engineer. He has a long, lonesome watch, with a light load and more leisure. Why should he not improve the time reading up on matters that will make him a better engineer. He has no time to read at home for when he is not trying to sleep he owes it to his wife and children to give them a little attention. When he has everything running smoothly at night, he can do a little reading without neglecting his duty in any sense. Who could criticize him if he made himself comfortable and dug into such questions as economical combustion, methods of analyzing coal, economizer losses due to scale, or any other subjects relating to power-plant operation and repairs?

The Night Engineer Off Duty

Speaking of the night engineer, have you never been one, or if you have, was it so long ago you have forgotten his hardship? If he is the average one, he has twelve hours on duty. Arriving home his wife is up to greet him and his youngsters too, if he has any. Then he has breakfast with them. After he eats he visits with them a little time, if he is not too dead tired, and then he goes to bed.

Meantime the noise and bustle increase out on the street and the night engineer is trying to sleep.

The sun grows hotter and hotter until his bedroom feels like the inside of a boiler off for cleaning, with a leaky stop valve; sleep is out of the question and the poor man gets up in the afternoon with probably no more than three or four hours sleep out of his twelve hours off. He must give his family some of his waking time before he goes back to the plant. Perhaps he has some errands to do, or a few odd jobs around the house. Then off he goes for another night's turn. This rather tedious cycle is repeated every twenty-four hours. Is it any wonder that one occasionally falls asleep on duty?

We must have a little charity for the night engineer.

Investigate Boiler Explosions

There is one thing that the law which the committee of the American Society of Mechanical Engineers is to recommend as a model for legislation to restrict the slaughter and damage occasioned by the abuse of boilers and other pressure vessels, should include. It should provide for a thorough investigation as to the cause of every serious accident to a boiler or to the sort of pressure vessel the use of which it is intended to regulate.

The Board of Boiler Rules, or some other competent body, should be authorized to carry out this examination, empowered to subpœna witnesses, to call for books, papers and other pertinent evidence, and be required to submit a report within a reasonable time to the governor, showing the cause and manner of the explosion, and fixing the responsibility. The owner and operator of a plant in which an explosion occurs should be required to immediately report the same to the investigating authorities, and penalties be provided for a failure to do so. Insurance companies should also be required to report claims for losses. In this way, a vast amount of valuable and authentic information regarding explosions would be accumulated, stress thrown upon the causes which most frequently produce explosions, and a way pointed out to avoid them.

Engineers' Study Course

With lesson XXX, which appears in this issue, the section of the Study Course on Elementary Mechanics is concluded. To the man working in the power plant who is desirous of knowing a little more of the theory of the machines, this course should be of value and help. He will find many cases where he can apply the more general laws discussed in the course to the solution of some particular problem that may confront him.

Many more and useful principles of mechanics might have been discussed but owing to the desire to avoid all complicated mathematics these have been omitted, especially the mechanics of liquids and gases.

It is hoped that all the readers of Power who have followed these lessons in mechanics may have gained some new insight into their various lines of work, and have had aroused in them a keen desire to know more about the "whys and wherefores" of their particular business.

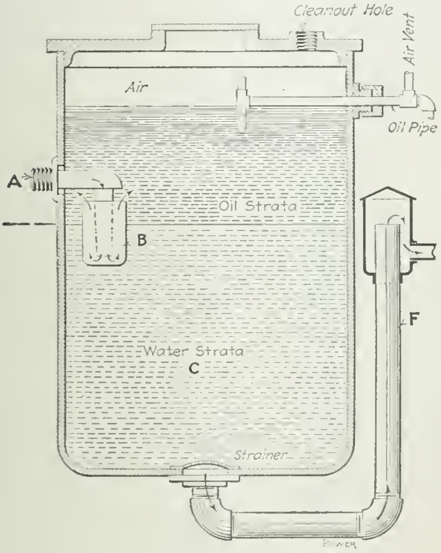
Beginning in the next issue, there will follow a series of thirteen lessons on "Problems in Power Plant Design" which will treat of the various problems entering into the design of the power and heating equipment of a large industrial plant.

Correspondence

Gravity Oil Separator

The oil and water separator described on page 279 of the Aug. 25 issue seems unnecessarily complicated.

A tank and water drain pipe, like the one described, and an oil pipe at a point higher than the level of the water drain pipe, are all that is necessary. At some high point in the oil pipe, there should be an opening to allow the air to escape. I do not understand how the water can be clean after it has been in such intimate contact with oil, or where else any heavy sediment could be expelled.



Simplified Oil Separator

Leon Lewis.

New York City.

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Machinist Engineers

I have read J. Thorn's letter on p. 930, June 30, and N. C. Gleason's, on p. 217, Aug. 11, under the above caption. I am not personally acquainted with the local conditions of the first, but Mr. Gleason is nearer my home town. Machinists do get 45 to 50c. per hr.; as to engineers, with but few exceptions, getting 30c. per hr. or less, I think it is easy to see where the trouble is.

Engineers of the class referred to are not mechanics, and cannot go very far trouble-shooting. As for Mr. Gleason's scruples against butting into another man's trade, while he is aiming to become proficient in handling electricity, is he not butting into the electrician's business? Electricians generally get higher pay than machinists.

Again, how does an engineer looking for advancement expect to qualify himself to take charge of large plants, where several fitters and machinists are employed on construction and repairs, if his knowledge is limited to what he has read in books? This kind of chief soon goes back to the 30c. per hour class.

The law in Alberta calls for 24 months of shop practice before a man can sit for a first-class license. I think it should call for 48 months' experience as a journeyman machinist in making and repairing steam engines and power-plant equipment. Having this knowledge in store, he will find it much easier and will not be compelled to call on outside help for anything which demands skill and practice. Furthermore, his employer is a poor business man if his pay does not correspond with his ability.

Benjamin J. Rendov.

Edmonton, Alta.

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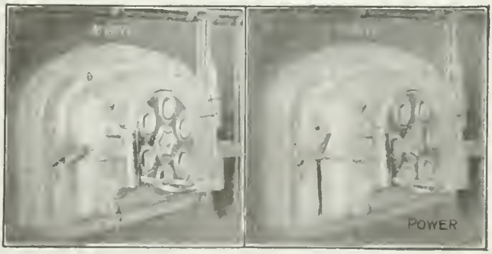
Safety Catch on Furnace Door

Some time ago Power had a cartoon showing what might happen to the attendant should a tube burst while he was in front of the door.

Having a number of large water-tube boilers under my charge, I decided to get up a device that would prevent such an accident. One illustration shows the door just before closing, with the catch raised ready to fall in place when the door is closed; the other has the catch down over the bar that locks it, and prevents it being forced open should a tube fail.



Catch on Ordinary Door

Thomas J. Pascoe.

Norway, Mich.

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Does Oil Attack the Engine Cylinders?

The engines in our plant are large triple-expansion machines, each having two very large low-pressure cylinders. The vacuum carried is rather high, averaging about 27 in. We have found it exceedingly difficult to lubricate the cylinders satisfactorily or so as to prevent a rapid wearing away of the cylinder walls. The engineer who erected the machines insisted on using oil in large quantities until the machine was thoroughly broken in, after which he said the quantity might be considerably reduced. We have found, however, that instead of decreasing the supply of oil, it has been necessary to increase it, or at least that is what we have done.

Recently there has been a great deal of discussion by our engineering force, and by others outside whose opinions have been sought. Out of this discussion comes the rather startling assertion that the rapid cutting away of the cylinders, which are made of a soft, coarse, gray iron, is due primarily to the use of such excessive quantities of oil. The opinion voiced is that the acid in the oil actually eats away the iron; it is so porous that this acid readily penetrates beyond the surface.

As this is something new to me, I should much appreciate knowing whether other readers of Power have had similar experiences, and have been able to trace them positively to the use of an acid-bearing oil.

B. F. Mayer.

Buffalo, N. Y.

Fusible Plugs

Prior to 1911, so far as I could find, a fusible plug had never been used in any of the 40 or more boilers with which I had to do, and some of them were of the latest water-tube type, and in large plants. Since then, I hope they have been so fitted. Builders of water-tube boilers do not make provision for fusible plugs except where required by law.

If composed of the proper alloy and kept free from scale, a fusible plug will melt when the water gets low enough to uncover it. I know of instances where serious trouble would have been prevented if the boilers had been protected by operative fusible plugs. In one case, the damage to the boiler was about $1000. In another, the alloy in the plug melted at low water but the coating of scale above it was so thick that it did not blow. Sometimes, the location of the plug as required by law is such that it is almost inaccessible from either side, and therefore is not kept free from scale or soot, which may prevent it from melting at the proper time.

The principal cause of low water in the boiler is the operator's neglect or carelessness. If he is watchful, he will know when anything is wrong or when the water is getting low, and will have time to either correct the trouble or get the boiler out of service before the water gets dangerously low.

Some type of fusible plug, as an independent low-water alarm, connected directly to the shell of the boiler should be required and independent of the usual high- and low-water alarm.

Feed-water regulators are a great help if properly used, but their automatic features sometimes cause the operator to become careless, and he does not watch the water level as closely as he should. Perhaps the regulator may get out of order or the feed be interrupted; then the water gets dangerously low before it is discovered.

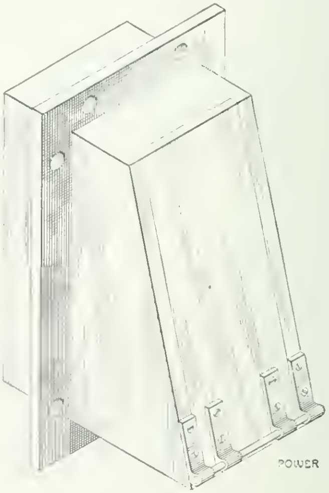
I have in mind a low-water alarm made of a piece of ¾-in. pipe extending through the top of the boiler down to the safe low-water level. The end outside of the boiler has a fusible head similar to an automatic sprinkler head, and above the fuse is a whistle. When the water in the boiler is at the proper level, this pipe is full of water and the temperature is low enough to prevent the fuse from melting. When the water lowers beyond the end of the internal pipe, the water is drained out and steam enters, melts the fuse and blows the whistle until it is shut off. A fault of this arrangement is that a valve is placed between the fuse and the boiler to permit a new fuse being inserted without letting the steam off the boiler. This valve is likely to become closed, thus making the alarm useless. Nevertheless, an independent low-water alarm is important as it gives warning before the danger point is reached.

J. C. Hawkins.

Hyattsville, Md.

Safety Door in Setting

The editorial of May 26, 1914, concerning safety dampers interested me so much that early in June I had two doors made as shown and set into the brickwork. This idea was suggested in a letter in Power by one who had experienced tube trouble. Some of my brother engineers seem to think it a joke to put a safety valve in the brickwork, but I think it is a good thing.



Door Set in Brickwork

Wallace Johnson.

Utica, N. Y.

'Twas Ever Thus!

Recently I had an amusing experience which illustrates the peculiar mental attitude assumed by some men. I was consulted by the owner of a small factory, who complained about the conditions existing in his power plant. The substance of his complaint was the excessive drop in pressure between the boilers and the engine—some six pounds. He had figured out the loss in money and had about concluded to spend some in reconstructing the piping system.

Upon visiting the plant, we arrived at the engine room. Here was a simple Corliss engine of about 250 hp.; a 6-in. steam pipe led to it. There was nothing to indicate an abnormal drop in pressure—in fact, the pipe was somewhat larger than I would have used under the circumstances.

Entering the boiler room from the rear of the boilers, I saw the usual style of connection, but nothing to account for the large drop in pressure. It seemed that a one-pound drop should have covered the case as the equivalent length of pipe was less than 100 ft. I was having visions of obstructions in the piping when, on reaching the front of boilers, found the steam gage down about 7 ft. from the floor and the connecting pipe rising from the top of the boiler so as to put a head of water on the gage that measured 10 ft. 6 in. Here was $4\frac{1}{2}$ lb. accounted for.

The explanation was satisfactory to the owner and he was much pleased that his trouble was really no trouble at all. The amusing (?) feature was that he did not consider my services worthy of compensation, for, as he expressed it, "Any —— fool could have told me what was the matter!"

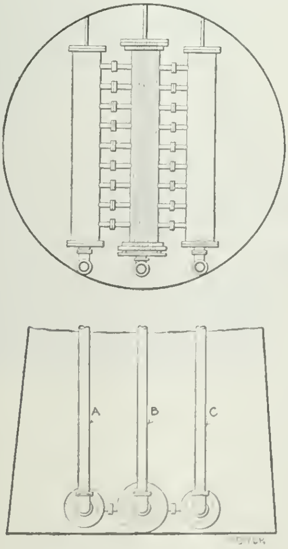
Had I recommended larger piping and work that would run up in cost he would probably have regarded me as being strictly onto my business.

C. O. Sandstrom.

Kansas City, Mo.

Water Heater in Supply Tank

An efficient submerged heater was constructed of old stock material and placed in a supply tank from a water-softening system, utilizing the exhaust from a 12x20x20x24-in. duplex pump. The tank was 18 ft. in diameter and 14 ft. high. The construction was as follows:



Heater Submerged in Tank

One length of 20-in. and two of 15-in. pipe were drilled and tapped, as shown in the illustration, and connected with $2\frac{1}{2}$-in. pipes. The larger pipe was flanged with a piece of $\frac{3}{4}$-in. boiler plate on each end, into which was expanded a number of old boiler tubes. On the front end was put a ring of 1-in. iron, which acted as a distance piece, allowing the distribution of the water through the tubes.

The steam enters through pipe *A* and flows through the smaller connections into the larger pipes; the vapor is conducted to the atmosphere through the pipe *C*. The condensate is drained through the sides of the tank and then pumped to the top. The feed water is admitted through pipe *B* into the tubes and flows out at the other end into the tank.

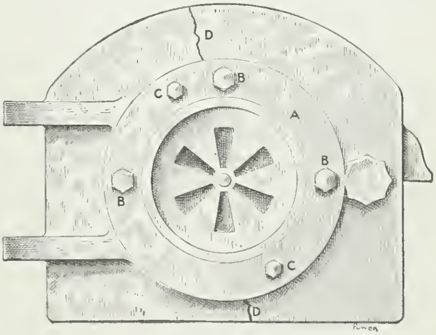
John F. Hurst.

Louisville, Ky.

Furnace-Door Repair

Up to a year ago, our furnace doors cracked and finally broke in two, as shown at *D* in the illustration.

To eliminate this trouble, we had several rings cut from boiler plate just large enough to fit over the rib around the damper, and $1\frac{3}{4}$ in. wide. These were drilled for the bolts *BBB*, which serve the double purpose of holding the ring and the door lining. The smaller bolts *CC* help to hold the two pieces together.



Furnace Door Repaired

We have fitted all of our doors with these rings and find that they give longer service without attention than would new ones.

George B. Longstreet.

Somerville, Mass.

Crack in Boiler Shell

A recent article on patching boilers recalled an experience I had with a 66-in. by 16-ft. return-tubular boiler, in which a fire crack developed, extending from a rivet hole above the fire-doors for 1 in. on the bottom of the fire sheet. As the boiler had a flush front, the fire sheet extended 16 in. beyond where the head joins the shell.

It was at first thought that the crack was caused by cold air entering through the panels in the fire-doors used in connection with a smoke preventer, but upon removing six rivets to insert a patch over a hole left by a piece cut out of the shell where the crack occurred, it was found that the rivet holes in the head and the shell did not correspond. This made it evident that the holes had been punched to size instead of being punched small and then reamed to the proper diameter to take the rivets; also, that a drift pin had been used freely in joining the head to the shell.

The boiler is of the triple-riveted, butt-joint type, constructed of $\frac{7}{16}$-in. metal and $\frac{7}{8}$-in. rivets; it was built for

150-lb. working pressure. To put it on the market in such a condition as representing, it is supposed, a piece of first-class workmanship and design, was hardly honest, and not only endangered the reputation of its builder, but the lives of those who operated it.

It would also seem that in the construction of steam boilers at a time when competition is keen and the cost of material is a large factor, that boiler makers, especially the small ones, are likely to neglect to remove enough metal from the edges of the rings when rolled. The edges, being cooled quicker than the interior of the shell, are in danger of hardening and becoming more brittle than that part of the shell which cools more slowly; therefore, the edges of the rings lack the toughness that should characterize a metal of high tensile strength.

Test bars should be taken from all boiler plate during construction, but where there is no law to that effect it is not always done.

La Rue H. Stark.

Delavan, Wis.

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Obtaining Smokeless Combustion

To the beginner the problem of obtaining smokeless combustion is generally very complicated, but if he will bear in mind one principle, it will go a long way toward helping him to understand many of the smoke-preventing furnaces. This principle is to so construct the furnace as to cause the gases to come in contact with a hotter surface before they reach that of the boiler. Hence the reason for the large combustion arch of the chain-grate furnace, the steam jets in other types, and for forcing the gases up through the incandescent fuel in the various underfeed types.

He will also understand the great benefit derived from high settings and when hand firing will note the advantage of allowing the fuel to coke on the dead plate. The object in each case is to lead the gases to a hotter place before they come in contact with the comparatively cool boiler surface.

John F. Hurst.

Louisville, Ky.

⁂

Feed-Water Heaters

Although considerable has been written about feed-water heaters, perhaps more on the subject will not be amiss, especially on the careless way in which they are installed. Very often the heater is in some out-of-the-way place and covered with dirt, when it should be accessible and kept clean, both inside and outside, to render efficient service.

In any plant where steam escapes from the exhaust pipe and the feed-water temperature is not 200 deg. or higher, there is something wrong with the size or management of the heater.

Some engineers pay but little attention to the temperature of the feed and are indifferent to the oft-repeated statement that 11 deg. rise in the temperature of the feed water will result in a saving of one per cent. in the coal bill.

The best type of heater to use depends on the working conditions of the plant. A closed heater is not suitable where the feed water contains much scale-forming substance or where the exhaust steam is intermittent, because the tubes will become coated with scale in the one case and the sudden changes in temperature will loosen them in the other. An open heater will give better results as it is much easier to clean and is not affected by sudden temperature changes. The efficiency of an open heater is reduced by feeding too much cold water and allowing the excess to pass off through the overflow.

Upon taking charge of a plant at one time, I was astounded at the size of the water bill, but I discovered that the float in the heater was inoperative. The fireman told me that my predecessor wanted the heater to overflow to flush out the oil and scum. After adjusting the valve rod I made a saving of $37 in the water bill the first month and raised the temperature of the feed water 16 degrees.

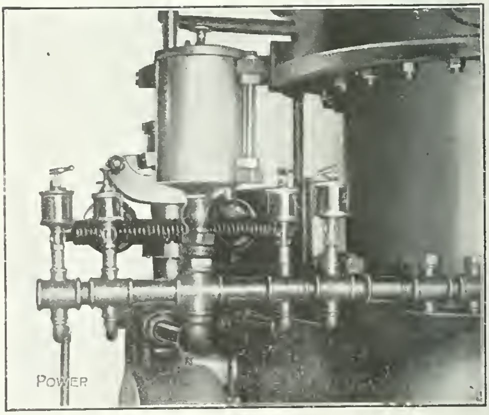
Louis B. Carl.

Marshfield, Wis.

⁂

Bracket for Oil Cups

The illustration shows a simple bracket for the oil cups on a Westinghouse gas engine. I put them all in one place and piped from them to the various bearings, as those on the governor side of the engine were scattered around, some in out-of-the-way places and unsafe to reach when the engine was running, and often neglected on that account.



Bracket and Cups in Place

The bracket is made up of 1x1x3/8-in. crosses, one 1-in. cross carrying the large cup which was tapped through and a long-thread nipple run through it with a locknut on the other side. The other cups were similarly fitted with 1/4-in. pipes. This places all the cups in a line and in plain view, so that none need be overlooked when filling: they are also much easier to regulate. The bracket was fastened to the crank-case of the engine by drilling two holes and putting in two 5/8-in. studs, so that two fittings would set down over them and be clamped rigidly in place by the nuts.

L. M. Johnson.

Emsworth, Penn.

Home-Made Cable Clamp

A large number of clamps, similar in construction to the one shown by Mr. Hodges, page 171, Power, Aug. 4, 1914, are in use on the Brooklyn Bridge at the cable crossing.

Their shape varies a trifle from the sketch shown, but the idea is the same, the cables on the bridge, however, crossing each other at the clamp.

Edward O. Johnson.

East Orange, N. J.

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Queer Compressor Diagram

While indicating an ammonia compressor recently, the indicator-needle valve leading to the cylinder was throttled. A diagram taken under this condition is shown in Fig. 1. On the compression stroke the pressure in the cylinder was not able to transmit itself fully to the indicator piston; on the suction stroke the pressure in the indicator could not relieve itself quickly and follow the low pressure in the cylinder of the compressor.

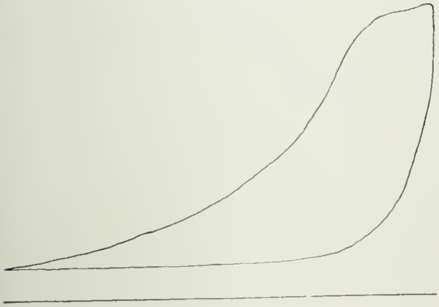


FIG. 1

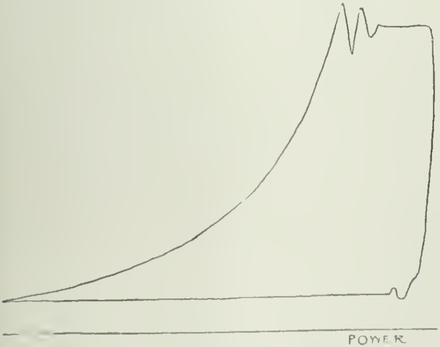


FIG 2

Diagrams from Ammonia Compressor

Without knowing that the valve was throttled, one might suppose that the compressor was in bad condition, the "thinness" of the diagram indicating piston- and suction-valve leakage, and the rounded "heel" showing excessive clearance.

The true diagram, taken with the valve open, is shown in Fig. 2, and it indicates that the compressor is in good condition.

There is little danger that such a freak diagram would be taken unintentionally, for the indicator valve had to be very nearly closed before any effect on the card was noticable.

G. H. Crawford.

Philadelphia, Penn.

⁂

Lowering Flywheel into Pit

Installing a large Corliss engine in an out-of-the-way place with but few tools, is a trying ordeal. I know it. A few pinch bars and a jack borrowed from a section boss constituted the entire equipment. All went fairly well until it came to lowering the one-piece flywheel into the pit. It occurred to me to partly fill the pit with dry sand. Then the wheel was rolled down easily and the shaft put into it. By digging the sand out the wheel settled down until the shaft rested in the bearings.

Philip R. Dunton.

McPherson, Kan.

⁂

Effect of Electrolysis on Boilers

This letter is written to bring out a healthy discussion on the above subject by those who have witnessed a similar phenomenon. A short time ago I was attracted by some boiler tubes and a head which were being loaded on a wagon. Knowing that this building had a comparatively new boiler, the need of such extensive repairs at so early a date was surprising.

It was a 42-in. by 12-ft. low-pressure boiler (10-lb. gage), containing 38 three-inch tubes and supplied heat to an office building and Turkish bath. The shell was of $\frac{1}{4}$-in. steel, with a handhole at the bottom of the front head and a 10x16-in. manhole at the top of the rear head. The boiler is insured and inspected at regular intervals, and is under the general charge of an engineer employed by the building owner, who comes over from his nearby plant every day to see to things in general.

While everything was normal, there suddenly came a roar of escaping steam from the back head, the gage at the time registering 2 lb. and the fire practically dead. At the top of the manhole, just at the bend of the flanged sheet, was a hole half an inch wide in the middle, tapering to the ends and 2 in. long, eaten entirely through the $\frac{3}{8}$-in. sheet. Corrosion was evident all around the manhole following a general line at the bend of the sheet, but it gave way at the top first.

The cast-iron manhole plate was eaten away all around the edges of the guide ring, mostly in one spot, but *not* opposite the worst place in the head, where the blowout occurred. There was no evidence of a leak around the joint or the rivets. The boiler had been cleaned eight weeks before, and was in excellent shape, both as to scale and condition of the shell generally. The scale was only a coloring on the sheets and tubes. All this action occurred in these eight weeks and probably from the following cause:

There was a long scraper kept on top of the boiler when not in use, the handle projecting about three feet in front of the boiler, while the other end hung down about even with the rear head, resting on the brickwork. It was the habit to hang an extension cord in the projecting handle of this scraper, and it is believed that the rod became charged, the current following down and jumping to the boiler and setting up electrolysis.

No moisture could drop down on the boiler or head, a leak is out of the question and the boiler is practically new, and has had proper care. Does this theory look reasonable? I trust that others will write of similar experiences, as I have not seen anything in POWER lately along this line.

GEORGE H. WALLACE.

Racine, Wis.

⁂

Expansion of Steam Lines

To the average engineer the expansion of steam lines is a mysterious affair, but if neglected in steam fitting he will sooner or later have lines which "somehow or other always leak."

When coupling up pipework he should never allow a strain which the expansion will increase; in other words, it is far better to have the pipe a little short when cold than to have it too long as the expansion, of course, will elongate it.

A handy rule to determine the amount of expansion is as follows: Multiply the difference in degrees temperature between the hot and cold pipe by the length of the pipe in inches and divide by the constant 150,000; the result will be the expansion in inches.

Example—Steam at 100 lb. pressure, temperature of atmosphere 80 deg. F., length of pipe 100 ft.

Temperature of steam at 100-lb. pressure = 337.8; then

$$\frac{(337.8 - 80) \times 1200}{150{,}000} = 2.062\ in.$$

or a little over $^1/_{64}$ of an inch per lineal foot.

JOHN F. HURST.

Louisville, Ky.

⁂

Knock in Low-Pressure Cylinder

Large vertical cross-compound engines sometimes knock or pound in the low-pressure cylinder. This usually occurs after the engine has been in service some time, and as the supporting base of the cylinder is generally of hollow construction, it acts as a sounding board and greatly exaggerates the noise.

The cause is that at the upper end of the stroke the piston, being supported only by the more or less flexible piston rod, is thrown against the opposite side of the cylinder by the impact of the entering steam. The operation of the admission valve being quick, the piston receives a tremendous side blow.

The effect is not evident at the beginning of the upstroke as the stuffing-box packing, etc., render the rod less flexible. The trouble is rarely experienced with the high-pressure piston as its rod is larger in proportion to the piston diameter. The best remedy is to remove the piston and increase the tension of the packing rings. With some types of pistons, removing the follower will allow access to the rings, and stiffening the packing offers more resistance to the throwing action of the steam.

Another way to stop the noise until the packing can be worked on is to increase the lead of the upper steam valve, causing a gradual action of the steam against the piston as it approaches the end of the stroke. The indicator will show excessive lead, but that is preferable to the noise.

JOHN F. HURST.

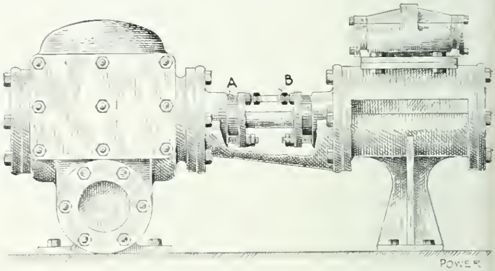
Louisville, Ky.

⁂

Emergency Pump Repairs

The gland studs on pumps often show distress, especially those aboard ship, or on pumps which circulate brine. The action of the salt water tends to rust out the threads and allow the stud to pull out.

The regular repair consisted of tapping out the hole to the next larger size and fitting in a new stud having a large end threaded to fit the new tapping. Conditions do not permit of this work being done at the time of the failure in every case, so that a temporary repair is necessary. The illustration shows how to tide over such an emergency in a thoroughly satisfactory manner.



LOOSE STUD MADE SECURE

Cut and thread a rod of the same size as the studs and just the length that will fit in between the ends *A* and *B* of the two opposite studs. With nuts screwed on flush with the ends, the new rod is then set in between the two studs and the nuts screwed half way on each stud, making a continuous rod of the three parts.

If it is desired to put an end pressure on the studs, the new rod may be unscrewed the desired amount when in place and after the first nut has been started on the stud and the other nut not entered. This will act as a jack screw and put an end pressure on each stud.

J. A. LUCAS.

Ozone Park, L. I., N. Y.

⁂

Graphite in Boilers

The boilers in the writer's charge are cleaned semi-annually. In February of this year the use of graphit was started. On Aug. 12 one unit was cut out and th drums were found coated with a thin, spongy scale, impregnated with graphite, but the tubes were lined with very hard scale $^1/_8$ in. thick with no graphite in it. Wh does graphite not affect the scale in the tubes?

I believe that where the circulation is not so rapi the graphite is able to work under the scale, but tha in the tubes no opportunity is given it to settle. Therefore, it is carried to the rear headers and the greater po tion settles into the mud drum and is blown out.

H. A. COX.

Middletown, N. Y.

Inquiries of General Interest

Steam Pipes Should Drain Away from Boiler—Should the steam pipe leading from a boiler to an engine incline up or down from the boiler?

S. H.

All steam mains should be so sloped that the water from condensation will drain away from the boiler, thus allowing gravity and the flow of steam to work together.

Purpose of Riding Cutoff—What is the object of a riding cutoff on a throttle-governed engine?

L. W. C.

To obtain adjustment of the point of cutoff to the load of the engine operating with higher initial cylinder pressure and thus obtain greater economy by working the steam expansively through the largest possible proportion of the stroke.

Pump Becomes Steam Bound—How can a feed pump with suction from an open heater be prevented from becoming steam bound without lowering the temperature of the water in the heater?

P. S.

Operate the pump at slower speed and feed more continuously, but if that is not practicable, lower the pump or increase the size of suction pipes and connections so the suction water will be delivered to the pump cylinder with less reduction of pressure from friction.

Heat Given Up by Cast Iron in Cooling—If a bar of cast iron weighs 30 lb., how many heat units will it give up in cooling from 850 deg. F. to 60 deg. F.?

M. S. M.

The specific heat of cast iron is about 0.1298, i.e., for each degree of rise in temperature, a pound of cast iron requires the addition of 0.1298 B.t.u., and in cooling it parts with the same amount of heat for each degree of reduction of temperature; therefore, 30 lb. of cast iron in cooling from 850 to 60 deg. F. would part with

$$30 \times (850 - 60) \times 0.1298 = 3076.26 \text{ B.t.u.}$$

One Side of Duplex Pump Quicker Than the Other—What would cause one side of a duplex steam pump to move more quickly than the other side?

A. J. O.

One side may run faster than the other, because its water piston is doing less work than the water piston of the slower side and needs packing; or one side may run slower than the other because the steam supply passage has become clogged, the steam valve does not open wide enough, the steam piston leaks, or the packing of the piston or of the piston rod is too tight.

To Operate One Water Piston of Duplex Pump—If the water piston on one side of a duplex pump were to become disabled, how could the pump be run with only one water cylinder?

J. O. C.

If the disabled piston is in a condition from which it is likely to injure its cylinder, it should be removed from its rod. For continuing the operation of the other water piston, place a blind gasket in the steam supply connection of the disabled side of the pump with a small hole in the gasket for admission of only sufficient steam for overcoming friction of the disabled side and for operating the valve gear of the good side of the pump.

No Load Loss of Transformer—What energy would be consumed by a 350-kw., 110 2200-volt, 25-cycle transformer, with the primary connected to the busbars, but the secondary disconnected from the line?

C. F. S.

The losses in a transformer consist of copper (I^2R) loss, and core losses. With the line switch disconnected and the transformer carrying no load, the copper losses would be negligible, but there would still be the core losses consisting of hysteresis and eddy currents, both of which are practically independent of the load. The hysteresis varies as the 1.6 power of the voltage and directly as the frequency. The eddy current loss varies inversely as the ohmic resistance and directly as the square of the voltage. The exact value of these losses in any case would depend upon the design of the transformer. With a transformer of 350 kv.a. capacity, these losses would probably amount to about 1 kw. per hour.

Load Raised by Plunger Elevator—What weight can be lifted by a direct plunger elevator operated with 160-lb. pressure per square inch, the diameter of plunger being 8 in., and the weight of the plunger and car being 1700 lb.?

T. J. M.

The total lifting force exerted by the pressure of the water on the plunger would be the square inches of cross-sectional area of the plunger multiplied by the water pressure per square inch or

$$(8 \times 8 \times 0.7854) \times 160 = 8042.4 \text{ lb.,}$$

allowing 5 per cent. loss due to friction of the plunger packing and guides, then the lifting power of the plunger would be

$$8042.4 \times 0.95 = 7640.28 \text{ lb.}$$

If the plunger and car weighing 1700 lb. are uncounterbalanced, then the net weight that could be lifted would be

$$7640.28 - 1700 = 5940.28 \text{ lb.,}$$

and if counterbalanced this would be increased by the amount of counterbalancing weight employed.

Meaning of Cycle in Engineering—What is the meaning of a cycle as used in engineering?

L. E. J.

In its broadest sense, a cycle is a period marked by the beginning and completion of a reoccurring round of events. Applied to thermodynamics, it is a series of operations in which heat is given to or taken away from a working substance (such as steam, gas, etc.) which, by expansion, gives up part of its internal energy in the form of mechanical work, and by compression or by the addition of heat has its internal energy restored and is brought back to its original state. Electrically, it means a complete positive and negative wave of electric current. In alternating current, a cycle embraces the complete period from zero voltage to maximum in one direction, returning through zero to a maximum in the other direction and back again to zero. In gas-engine terms, a cycle is one complete series of events. For instance, a "four-stroke cycle" means that it takes four strokes to complete the operation. The mixture starting with the intake on the first stroke, is compressed on the second (return) stroke; its ignition and expansion take place on the third stroke, and the gases are expelled on the fourth or exhaust stroke, whereas in the "two-stroke cycle" engine these events are accomplished in two strokes.

Horsepower of a Waterwheel—What is the formula for computing the number of horsepower of a waterwheel?

W. H.

If

Q = Number of cubic feet of water discharged per minute;

D = Weight of a cubic foot of water = 62.36 lb. (at 60 deg. F.),

and

H = Total head in feet,

then the gross power or horsepower of the water is

$$\frac{Q \times H \times 62.36}{33{,}000} = 0.00189\,QH$$

But a waterwheel or motor cannot utilize the whole of the head as there are losses of head at the entrance and exit and also losses of energy due to friction of moving parts of the wheel. The fractional part of the power of the water which the waterwheel is capable of delivering as useful power is called the percentage of efficiency of the wheel. Calling E the percentage of efficiency then for Q cubic feet of water per minute and H total head in feet,

$$\text{Hp. of the wheel} = 0.00189\,QH \times E.$$

The value of E varies with Q, H and the r.p.m., and with most types of turbines it also varies with the amount of gate opening. A fair average for a good turbine wheel may be taken at 75 per cent. efficiency, but the efficiency assumed for any case must be that which has been determined for a given set of conditions.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXX

LAST LESSON'S ANSWERS

136. In Fig. 85 let the distance between the centers of the pulleys M and N be 10 ft. or 120 in. Draw the line of the belt. Its arc of contact on the small pulley will be the angle BAE which is equal to 180 deg. minus twice the angle DAB. From the center of the small pulley N draw the line AR parallel to the line CB. Then since the line AR is at right angles to the line AB and the line AO makes 90 deg. with the line AD it is evident that angle DAB = angle a = angle RAO. The line OR is equal to the radius of the large pulley minus the radius of the small pulley or line OR = (15 — 9) = 6 in. The sine of the angle RAO is equal to $\frac{OR}{OA} = \frac{6}{120} = 0.05$ and from a table of sines the value of a is found to be (2 deg. 50 min.). Therefore, the arc of contact is

(180 — 2 × 2 *deg.* 50 *min.*) = 174 *deg.* 20 *min.*

137. From equation (83) $log_{10}\left(\frac{T_1}{T_2}\right) = 2.73 \times f \times N$, where f = the coefficient of friction = 0.3, and N = the ratio of the arc of contact in degrees to 360 deg. or

$$N = \frac{174 \text{ deg. } 26 \text{ min.}}{360} = 0.484. \text{ Hence}$$

$$log_{10}\left(\frac{T_1}{T_2}\right) = 2.73 \times 0.3 \times 0.484 = 0.396$$

and from a table of logarithms the value of $\frac{T_1}{T_2}$ is found to be 2.49 or $T_1 = 2.49\ T_2$.

138. Since the belt is 12 in. wide and good for 60 lb. per in. of width the maximum tension T_1 that may be put on the belt = (12 × 60) or 720 lb. The effective driving effort $P = (T_1 — T_2)$ and from the above problem $T_1 = 2.49\ T_2$, or $T_2 = 0.4\ T_1$; hence

$P = (T_1 — 0.4\ T_1) = 0.6\ T_1 = (0.6 \times 720) = 432$ *lb.*

The linear velocity of the belt = r.p.m. × the circumference of the smaller pulley or

$V = 300 \times 3.1416 \times 1.5 = 1413$ *ft. per min.*

and from equation (55)

$$hp. = \frac{P \times V}{33{,}000} = \frac{432 \times 1413}{33{,}000} = 18.5$$

139. The rule states that a belt traveling at 900 ft. per min. will transmit one horsepower per inch width of belt. If traveling at 2700 ft. the belt will evidently transmit $\frac{2700}{900}$ or 3 hp. per inch of width and as the total width of the belt is 15 in. the total horsepower transmitted will equal 15 × 3 or 45 hp.

140. The horsepower transmitted by a double belt = 1.4 times that of a single belt, hence in this case a double belt would transmit 1.4 × 45 or 63 hp.

REVIEW

Mechanics is that branch of science which has to do with forces and their action on bodies tending to produce a state of motion, change of motion, or condition of rest of these bodies. This study of forces is divided into two general classes of statics and kinetics, the former dealing only with forces which keep a body in a state of rest and the latter dealing with forces which produce motion. The first nine lessons of this course covered the general idea of statics and Lesson X gave a résumé of the conditions which produce a state of equilibrium of all the forces acting so as to insure a state of rest of the bodies.

In Lessons XII, XIII and XIV, these laws of equilibrium were applied to the various forms of machines such as levers and pulleys including the Weston differential pulley. This idea of a machine naturally led to Lesson XIV where a few general notions of friction were given. It was shown that the force of friction acting between two bodies was directly proportional to the coefficient of friction times the normal pressure between the objects. To find the normal pressure it is necessary to resolve all the forces acting on the body into their components at right angles to the bodies. The algebrai sum of all these components will give the total pressur tending to produce friction. The algebraic sum of th components parallel to the bodies will produce or ten to produce motion of the bodies one on the other.

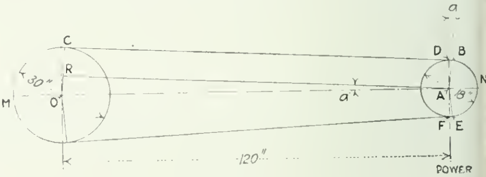


FIG. 85.

With the force of friction overcome, the next logica step is to study the laws which produce motion of bodie and to determine under what conditions a system o forces will be in equilibrium even *though the object are in motion at a uniform rate of speed.* In Lesson X the general conception of motion was dwelt upon an as in statics so in kinetics it was found that velociti might be represented by straight lines; that they migh be reduced into components in any desired direction, an moreover that a system of velocities could be replace by a single velocity which would produce exactly the sam motion as the combined action of all the other veloc ties.

The relations between the acceleration, velocity, tin and space traversed by bodies were worked out in consi erable detail and for handy reference these formulas* ma be summarized as follows, first, however, dividing mo ing bodies into six general classes, thus:

Class I—Bodies having uniform motion.

Class II—Bodies starting from rest and moving wi uniformly accelerated motion.

Class III—Bodies moving with an initial velocity a then acted upon by an accelerating or retarding force.

---

*The numbers opposite the equations are the same as us in the various lessons.

Class IV—Bodies falling freely under the action of gravity.

Class V—Projectiles, subdivided into,

(*a*) *Bodies projected horizontally from a point at some elevation above a given reference plane.*

(*b*) *Bodies projected at an angle to the horizontal.*

Class VI—Rotating bodies.

All problems coming under Class I may be solved by the relation that,

$$S = V \times T \qquad (27)$$

where

V = The uniform linear velocity in feet per second;
S = The space traversed in feet and;
T = The total time of motion in seconds.

Problems coming under Class II are solved by the following laws:

$$V = a \times T \qquad (30)$$

$$S = \tfrac{1}{2} a \times T^2 \qquad (31)$$

$$V^2 = 2\,a \times S \qquad (32)$$

where

V = The final velocity in feet per second;
S = The space traversed in feet;
T = The total time in seconds, and;
a = The acceleration in feet per second per second.

The formulas for problems coming under Class III are:

$$S = U \times T \pm \tfrac{1}{2} a \times T^2 \qquad (34) \text{ and } (38)$$

$$V_1 = U \pm a \times T \qquad (35) \text{ and } (39)$$

$$V^2_1 = U^2 \pm 2\,a \times S \qquad (37) \text{ and } (40)$$

where

U = The initial velocity in feet per second;
V_1 = The final velocity in feet per second;
S = The space traversed in feet and:
a = The acceleration or deceleration in feet per second per second.

The relation between the various items for falling bodies under Class IV are:

$$V = g \times T_1 \qquad (41)$$

$$H = \tfrac{1}{2} g \times T^2_1 \qquad (42)$$

$$V^2 = 2\,g \times H \qquad (43)$$

where

H = The height of fall in feet;
V = The velocity at the end of a fall of T_1 seconds duration, and;
g = 32.16 = the acceleration in feet per second per second due to gravity.

The laws for projectiles under Class V, Case *a*, are expressed by the relations:

$$T_1 = \sqrt{\frac{2\,H}{g}} \qquad (67)$$

$$R = V \times T_1 \qquad (68)$$

$$R = V\sqrt{\frac{2\,H}{g}} \qquad (69)$$

and for Class V, Case *b*:

$$T_1 = \frac{2\,V \times \sin a}{g} \qquad (70)$$

$$R = V \cos a \times T_1 \qquad (71)$$

$$R = \frac{V^2 \sin 2\,a}{g} \qquad (72)$$

$$H = \frac{V^2 \sin^2 a}{2\,g} \qquad (73)$$

where

T_1 = The total time of flight in seconds;
H = The maximum altitude reached by the projectile or is equal to the elevation of the point of projection in feet;
R = The range in feet;
V = The initial velocity of projection in feet per second;
a = The angle of projection in degrees and;
g = 32.16 = the acceleration in feet per second per second due to gravity.

The most common law for rotating bodies as described under Class VI may be stated as an equation which gives the centrifugal force of a weight of W pounds, rotating at N revolutions per minute at a distance of R feet from a fixed point of rotation, thus,

$$C = 0.000341\,W \times R \times N^2 \qquad (80)$$

With the idea of motion clearly fixed in mind, it is an easy step to the conception of the term work which has been defined as the overcoming of a resistance through a given distance. The formulas for the work done by various types of machines such as engines, pumps, motors, etc., are almost innumerable. If the student will very carefully analyze his problem he will find that in all probability all his examples relating to work may be solved by the general equation that.

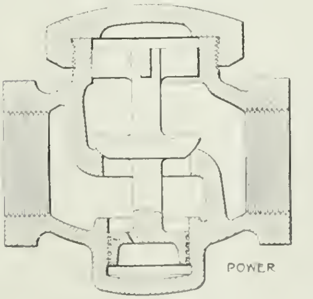
$$\text{horsepower} = \frac{\text{force in pounds} \times \text{distance in feet}}{\text{time in minutes} \times \text{efficiency} \times 33{,}000}$$

Indicated horsepower, brake horsepower, output and input of pumps, generators, etc., may all be found by applying the above equation with the use of the proper *coefficient of common sense, which is, after all, the most essential factor in the solution of any and all problems no matter how simple or how difficult.*

⁂

Powell White Star Dashpot Check Valve

This check valve is designed to be placed on either a suction or discharge line, and on the pipe line between the discharge end of an air compressor and the receiver tank. It is guaranteed to be noiseless and airtight and easily reground. The dashpot disk has wings on the upper end which act as a guide so that the disk will seat centrally in the valve body. The lower end of the disk in the dashpot of the body forms a cushion, thereby preventing the disk from pounding heavily on the valve seat.



SECTION THROUGH DASHPOT CHECK-VALVE

There are only three parts and they are interchangeable. The valve is made in sizes from ⅛ to 3 in. by the William Powell Co., Cincinnati, Ohio.

⁂

ERRATA—On page 473, Sept. 29 issue, the statement that the average weight of heaped **coal** is 30 lb. per cubic foot is an error as it should read **coke** instead. On page 468 of the same date the weight of a cubic foot of heaped coal is correctly stated as 51¾ lb.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Oh, Rustem Bey, you've gone away;
Let's hope your guff will cease.
While Turkey's never known us, Bey,
We've been all over grease.
—Engine-Room Ballad.

⁂

Here in New York they say we're suffering from departmental inertia. Reckon they're right if "inertia is the inability of a body to change its condition of rest or motion unless some force acts upon it." Nobody home?

⁂

Man died recently who was known as "Happy Days" Pittman. The title sounds good. Lines are so tightening around us these days that the "smile" wrinkles are giving way to frowns, the grouch is infecting us, and the kicker makes more noise than the funny sheet. "Happy Days" and "Smiling Johns" are too infrequent. Be one, and get popular. As the coon said about the battle, "You-all has a right smart day for it!"

⁂

Another rotary engine has been discovered by a daily paper out in Pun-Punk— Let it go at that! Of course, it's going to mark an ee-poch in the history of steam power. "This 8-hp. engine might be placed in an ordinary cheese-box," says this paper. Perhaps it will be.

⁂

If the operating engineering business gets dull, you might start something—say a skunk farm. Man in Greenfield, Calif., did this on a small scale, and now he is on the way to wealth. He says they just love human companionship and become great pets. But don't get 'em real angry; they stop loving you then!

⁂

Our much esteemed contemporary "Buildings and Business Management" is a paper after our own heart. The October front cover has John Bunny and his yard-wide smile just reaching right out to the reader. Underneath, is the caption "Smile! Business Is Good. Help Make It Better!" Here's optimism for you, and more—it's sound common sense! Root for good times and we'll have them, feller. Buck up!

⁂

The Franklin Institute Year Book for 1914 has reached us. But the big place the Institute occupies needs no meed of praise from us. Of this truly great institution may be repeated, without irreverence, Washington's encomium of Benjamin Franklin—it is "venerated for benevolence, admired for talents, esteemed for patriotism, beloved for philanthropy."

⁂

"The Right Time to Eat" earns an editorial for itself in the "Scientific American," and it extends from glycogenic functions right up to 8 o'clock p.m. We hold with Woods Hutchinson that the right time is when we're hungry, and then eat just one square meal; no more.

⁂

"Bursting Boiler Spreads Panic Among Widows," says a daily paper. Hey, editor, why start picking on the widows? If your wife were a widow you wouldn't be busting boilers in this loose fashion. You'd be shov—. Well, you're the best judge of what you'd be doing.

⁂

Through the generosity of Frank Thomson, there is a fund whereby sons of living and deceased employees of the Pennsylvania R.R. are being educated in technical schools. Power-plant owners and managers, please take notice.

⁂

What Sherman said war was still goes. But our cartoon foreword in this issue brings it into more intimate relation by labeling it "The paralysis of industry." Perhaps no man more nearly works by the sweat of his brow than the fellow in the boiler room. And to take away his means of livelihood creates a veritable Gehenna for him and his. Let us be thankful for peace and our jobs.

⁂

We have about a million boilers in this country of less than a hundred million people. Looks like we need those standard specifications right quick. Don't want to talk politics, but the governor, the mayor and the legislature feller who refuses to do his little bit to help lessen the explosion hazard from now on, won't get our vote.

Protecting Three-Phase Motors

By Albert M. Robinson

When three-phase motors are automatically controlled, a fuse sometimes blows, and when the control switch is closed, the motor will not start single phase, but will draw an excessive current, which if allowed to continue will burn the windings. If the motor is operating when the fuse burns out, it will continue to operate single phase and do no harm, but as soon as it stops, the current should be shut off.

Referring to the diagram, *B* and *C* represent the self-starter switches and *A* a relay. These are operated by solenoids; that is, solenoids when energized bring the two surfaces of the switches together by a clapper action; they are then held magnetically or mechanically by dashpots. The relay is constructed along the same lines except on a smaller scale, as it is designed to carry a small current for a short time only.

It is customary to have one line connected solid to the motor as 3. Lines 1 and 2 are left open to be closed by the self-starter switches *B* and *C*. Lines 3 and 2 are connected momentarily through the solenoid of the relay *A*, and when this relay is closed, then 3 and 1 are connected momentarily through the solenoid of switches *B* and *C*.

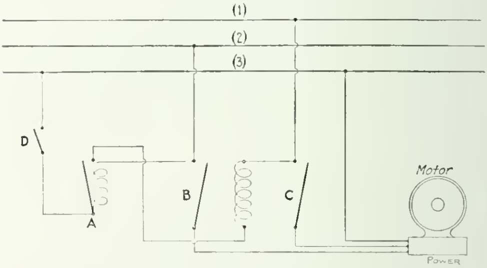


Diagram of Relay and Self-Starting Switch Circuits

The sequence of operation is as follows: When the control switch *D*, which may be a snap switch for remote control, float switch or pressure regulator, is closed, current passes through the solenoid of the relay *A*, and when the solenoid is sufficiently energized the relay is closed, causing sufficient current to flow through the solenoid of the self-starter switches *B* and *C* to close them. When *B* and *C* are thus closed, all three lines are connected to the motor and it will operate.

If line 1 is severed by a burnt fuse or otherwise, when the control switch *D* is closed the relay will be closed, but as no current can be passed from 3 to 1 on account of 1 being severed, the self-starter switches cannot be closed nor the motor operated. Should line 2 be severed, the relay *A* will not be closed, hence there will be no operation. Likewise, should line 3 be severed, no current will reach the relay, and the motor will not start.

Another method sometimes used consists of using overload relays, but on account of its greater cost, the above-mentioned method recommends itself.

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A Surplus of $80,000, after deducting all expenses, including a large depreciation reserve, is the record shown by the annual report for the municipal electric-light plant of Winnipeg, Can. A significant fact is that less than 15 per cent. of the gross revenue is derived from municipal works.

Gas-Engine Valve Setting

By G. W. Muench

SYNOPSIS—Discussion of the causes leading to altered valve timing and simple directions for the proper resetting of the valve-gear.

Trouble is often caused in reassembling the valve-gear after the engine has been taken down for repairs. The novice who tries to overhaul an engine invariably has his troubles when it comes to the resetting of the valves. Many mechanics in the repair shops get the valves set "somewhere near correct" and let it go at that, the result being loss of power, misfiring, overheating, inefficient operation, etc.

The valve-operating mechanism, ordinarily called valve-gear, depends upon the shape of the cylinder and valve arrangement, and, therefore, varies in detail with different engines. However, regardless of the valve-gear arrangement and the number of cylinders, the camshaft of a four-stroke-cycle engine must always operate at one-half the crankshaft speed since it requires two revolutions of the crankshaft to perform a cycle. For this reason the cam-gear ratio is one to two, the larger gear being on the camshaft.

Valve-gear troubles causing a change in the valve timing and valve lift are due mostly to wear of the various parts, unless improperly assembled; a few of the common defects are as follows:

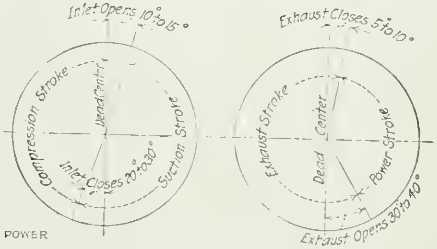
Worn cams, push rods, and rollers will reduce the lift of the valves besides changing the timing. If the cam is worn badly it should be replaced unless part of the shaft itself, when, of course, the entire shaft must be replaced. Worn push rods not only change the valve timing, but cause the engine to run noisily. In order to prevent this noise the distance between the push rods and the valve stems should be about $\frac{1}{32}$ in. and somewhat more for large engines. This clearance should not be too small, as otherwise the valves will not be allowed to seat when the engine becomes hot, due to expansion of the parts. For this reason it is well to adjust this clearance when the engine is hot.

Worn cam gears also cause enough lost motion to slightly change the valve timing; this, however, will hardly be as objectionable as the noise caused by these worn gears. An inexperienced operator often imagines his engine ready to go to pieces because of the noise caused by the lost motion in the cam gears. Gears improperly meshed are due to an error in assembling and more often ignorance of the man doing the work. Even one who does not know how to set the valves should not get into this trouble, as it is necessary only to mark the teeth on the gear so as to avoid mistakes in reassembling. Worn camshaft bearings change both the timing and the lift of the valves. If the bearings are really badly worn the lift will be so much reduced as to considerably affect the free passage of the gases.

Loose cams will cause a change in the valve timing and produce grinding and thumping. If the cams are keyed the keyways or keys themselves may be worn; or if pinned the holes may be worn, in which case they should be reamed out before putting in the new pins. Often pinned cams will shear the pins and slip a little and then become jammed.

Some engines have two camshafts, one for the inlet valves and one for the exhaust valves. Trouble with either will, of course, affect the running of the engine; it will change the setting of either the inlet valves or the exhaust valves, not both. If worn cams have lessened decidedly the total duration of valve opening a segment can often be dovetailed into the cam so as to hold the valve open longer. If this is done it should be on the closing face as wear is less on that surface.

The exact time at which the valves of a four-stroke-cycle gas engine should open and close depends upon a number of conditions; however, the speed is the principal factor that determines the setting. Just where to draw the line between high- and low-speed engines is not easy, but ordinarily, so far as velve setting is concerned, an engine is high speed when running at 600 or 700 r.p.m. and over.



Valve Diagrams

Valve timing is expressed in degrees of crank angle, that is the angle formed by the crank with the center line of the cylinder at the time the valve starts to open or is closed completely. Automatic valves, of course, can have no predetermined time of opening or closing as they are not mechanically controlled. Engines with offset cylinders are timed the same as those having the center line of the cylinder in direct line with the crankshaft, the only difference being in locating the exact dead center. The valve setting for slow-speed engines should be as follows:

The intake valve should open about 10 degrees past dead center at the beginning of the suction stroke, and should close at from 10 to 15 degrees past dead center at the beginning of the compression stroke. The exhaust valve should open about 30 degrees before dead center at the end of the power stroke and close about 5 degrees past inner dead center at the beginning of the suction stroke.

The valve timing for high-speed engines should be as follows: The higher the speed of the engine the less the time required to fill the cylinder with fresh gas and to exhaust the burnt gases; therefore, the greater the angle of advance necessary with the valves. The inlet valve should open about 15 degrees past dead center at the beginning of the suction stroke, and close about 30 to 35 degrees past outer dead center at the beginning of the compression stroke. This setting allows considerably more time for the engine to get a cylinder full of gas at the higher speed, allowing the valve to remain open through a greater angle. The exhaust valve should open about 40 degrees before outer dead center at the end of the power stroke and close about 10 degrees past dead center after completing the exhaust stroke.

This setting also gives the engine at this higher speed a better opportunity to get rid of the exhaust gases. Even though the valve setting is not as accurate as it should be, the exhaust valve should never close before dead center at the end of the exhaust stroke. Nor should the intake valve ever open before the exhaust valve has closed. The intake should open about 5 degrees after the exhaust has closed.

To the average operator it seems strange that the exhaust valve is made to open before the power stroke has been completed, and that the intake valve is allowed to remain open even after the compression stroke has started. Although it may seem that the engine is robbed of part of its power stroke as well as of part of its compression stroke, as a matter of fact, the operation of the engine, both from a standpoint of power and economy is bettered. During the suction stroke the gases enter the cylinder at a velocity of 4000 to 5000 ft. per minute. Traveling at this velocity the gases have enough momentum to keep them going into the cylinder for a short time even after the piston has already started on the compression stroke. This insures getting a cylinder full of fresh gas.

If the mixture is correct the combustion of the gases should have been completed long before the end of the power stroke is reached, and during the last 30 to 40 degrees crank travel on the power stroke comparatively little expansive power is left in the expanding gases. For this reason the exhaust valve is opened before the stroke is completed as the extra time thus allowed for exhausting the burnt gases is of more importance than the little power that might be left in the gases.

A simple problem will serve to illustrate the method of finding the valve setting of an engine. Assume the engine to have a 70-in. flywheel, then the circumference equals 70x3.1416, or 219.9 in. To determine the time at which the intake valve opens place the engine on inner dead center at the beginning of the suction stroke. Having marked the dead center on the flywheel, turn the engine in the proper direction until the valve just starts to open, mark this position on the flywheel and measure the distance to dead-center mark on the flywheel. We will assume this distance to be 5.75 in. This in terms of the crank angle equals $5.75 \div 219.9 \times 360$, or very nearly 9.4 degrees. Or by dividing 360 by 219.9 gives the degrees per inch or approximately 1.63 degrees. Now all that is necessary to get the crank angle for the valve setting is to multiply the distance on the flywheel between dead center and time of opening or closing of the valve by 1.63, which would be $5.75 \times 1.63 = 9.37$ degrees.

Notes on Commutation*

Blackening of the commutator, high mica, and rapid wear of the copper and brushes may be credited to actual burning or something similar to electrolytic action, occurring under the brushes. It is usually not the bright sparks at the brush tips which cause trouble, but the unnoted sparking under the brush face. There is a tendency for minute particles of the conducting material to be burned or carried away from the contact surfaces, depending on the direction of the current. These particles appear to travel in the direction the current is flowing, but do not always deposit on the opposite contact surface. If the current is from the brush to the commutator, the brush surface tends to be eaten away. With ordinary current densities and low loss in the brush contact, this action seems minute, but appears to increase rapidly with increased loss at the brush contact. Therefore, high current density in the brush contact may produce this action. This does not mean high density due to the working current alone, but the high actual density, due to both working and local currents. In noncommutating-pole machines and in commutating-pole machines with bad adjustment, the local current under the brush may exceed the working current. As this adds to the working current at one edge of the brush and subtracts from it at the other edge the result will be a greatly increased density under one part of the brush, which may mean burning away one edge of the brush surface. This usually is most noticeable where the current passes from the brush to the commutator, but at the holders of the other polarity, a similar action is tending to burn away the commutator copper.

HIGH MICA

However, the commutator mica does not tend to burn away, and if the mica does not wear down mechanically at the same rate that the copper burns away, eventually the mica stands an infinitesimal amount above the copper. Therefore, the brushes will make poorer contact with the copper. This increases the loss at the brush contact and increases the burning action, resulting in still poorer contact, so that the trouble becomes cumulative. If, however, these periods of burning are intermittent, due to variable load conditions, and there is considerable operation at lighter loads or nonburning conditions, the mica may wear down somewhat and the commutator and brushes may polish sufficiently during these periods to mask the direct effects of the burning. But the results may show in grooving and apparent rapid wear of the commutator face. There may thus be burning without blackening, or without direct evidence of high mica.

Where one edge burns over a distinct area, it usually may be assumed that the burnt area could just as well be cut away, with but little harm to the operation, and possibly some good, for the fewer the commutator bars that the brush spans, the lower will be the total short-circuit current, as a rule. Moreover, by doing away with the localized burning under the brush, it may be assumed that the commutator burns less also. Cutting away part of the brush face, however, will crowd the working current into the remaining portion where burning may be increased. Therefore, narrowing the brush face is not a general remedy for the trouble, although successful in some cases.

DEPOSITS OF COPPER ON BRUSH

Burning of the commutator may also be coincident with a deposit of copper on the brush face. This gives the equivalent of low resistance brushes, with consequent increase in local current and still greater burning action. Moreover, with several brushes in parallel, any brush with copper on its face, may tend to take more than its share of the total working current, which tends to cause further heating and burning. Increased heating in itself will cause a greater tendency of the brush to take an undue proportion of the current, for carbon brushes have a negative coefficient of resistance. Such action, if continued, will eventually so destroy or injure the brush contact that it carries a decreased current, the resistance increases, and eventually the current falls, not only to normal, but probably far below normal value, due to bad contact, and the other brushes must then assume an excess. If other brushes repeat this action then the conditions become increasingly bad for the remaining brushes, and they may repeat the same action. In time, all the brushes may thus become badly burned or honey-combed.

Such conditions are often difficult to correct. In some instances, higher resistance brushes bring improvement, while in others, lower resistance brushes are better. If the local currents are relatively small and the burning or picking up of copper is due principally to the working current, then a lower resistance brush may actually reduce the watts at the contact, even though the local current may be increased.

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*Excerpts from a paper by B. G. Lamme before the Association of Iron & Steel Electrical Engineers

If, on the other hand, the local currents are high and are principally responsible for the burning action, a still higher resistance brush may reduce the loss.

UNDER-CUTTING MICA

Another remedy for some of the foregoing troubles is under-cutting the mica between commutator bars. This does not remove the primary cause of the trouble, namely, the large local currents or high current density on the brush contact, but it lessens the harmful effect of these by allowing the brush to maintain better contact with the commutator. In this way the burning action can be diminished, in most cases to such an extent that the commutator face will polish, and this in turn will enable the brush to make better contact with the copper. Undercutting in general is advantageous where the mica takes up a relatively large portion of the total surface, such as 20 per cent. or more. The general practice at present with non-undercut commutators is about $\frac{1}{32}$ in. thickness between bars; considerably less than this, as low as 0.018 to 0.020 in. is not unusual in small machines which are not undercut. Where the commutators are undercut, there is a liability of carbon dust collecting in the slots and short-circuiting between bars, unless the peripheral speed is sufficient to keep the slots clear. Therefore, in slow-speed commutators which are undercut, it may be necessary at times to brush out the slots. In high-speed commutators, or in variable-speed machines which intermittently reach high speeds, there is usually but little difficulty from carbon collecting in the slots.

Slotted commutators, while advantageous in some ways, present certain operating objections in others. Except where the brushes cover several bars, the slotted commutators are likely to produce chattering of the brushes, unless frequently lubricated. Therefore, with such commutators, self-lubricating brushes are recommended. These brushes usually contain, or consist of graphite, and generally are of lower resistance than ordinary carbon brushes; therefore, they are not as useful in assisting commutation. In commutating-pole machines where the resistance of the brushes is of relatively less importance, graphite brushes are often satisfactory. As such brushes are usually soft, they are not well adapted for wearing away the mica in commutators which are not undercut.

COMMUTATING-POLE MACHINES

In the application of the commutating pole to direct-current machines, certain conditions have arisen which are peculiar to this construction. For instance, according to theory, the flux of the commutating pole should rise and fall directly in proportion to the armature current. This means that there must be practically no saturation in the commutating-pole circuit. Probably many of the early difficulties of commutating-pole machines were due to a lack of appreciation of this point. Also, in machines with rapidly changing current, the commutating-pole flux should change at the same rate as the armature current, otherwise the proper local current conditions for commutation are not obtained. This means that the commutating field winding should not be adjusted or varied in strength by means of a noninductive shunt, as is common practice in adjusting series field windings. As the commutating-pole winding is normally inductive, then in the case of a sudden change in current, an improper proportion of the current will flow through a non-inductive shunt at the time that the armature current is changing. Either no shunt should be used, or, if one is necessary, it should have the same inductance as the commutating field circuit. The former is preferable but requires most accurate designing.

Another requirement in commuting-pole machines is accurate setting of the brushes. As a certain definite value of the local or commutating current is desired in the short-circuited coil, it is obvious that the coil must be short-circuited by the brushes at some definite position with respect to the commutating pole. This is especially true in reversing machines. Otherwise, the commutation in the two directions would not be alike. Furthermore, an incorrect setting of the brushes, with respect to the commutating pole, will have a slight effect on the inherent regulation of the machine. In a direct-current generator, for instance, with the brushes set so that commutation is exactly central to the commutating pole, the magnetic flux of these poles has no resultant effect on the generated electromotive force of the armature winding as a whole, and therefore has no effect on the regulation. But if the brushes are shifted ahead of this correct point in a generator, part of the commutating pole flux becomes effective in generating an electromotive force in opposition to the armature electromotive force. A backward lead in the same way would tend to increase the armature electromotive force. Thus the inherent regulation of the generator is affected by the brush setting. In a motor with commutating poles, a forward lead of the brushes tends to increase the counter electromotive force generated and thus tends to lower the speed with increase in load, while a backward lead tends to increase the speed. With perfect setting of the brushes with respect to the commutating poles, and an adjustment of the commutating pole strength just sufficient to give the theoretically ideal short-circuit or commutating current, the commutating poles should have practically no effect on the speed.

In actual practice, in direct-current motors, it is found better to over-compensate slightly—that is, to make the commutating pole slightly stronger than the ideal value. This increases the local or commutating current above the ideal value so that commutation is well completed before the coil leaves the brush. This gives less sparking at the brush edge, and apparently is more satisfactory from the operator's standpoint. But this overcompensation has an effect on the speed characteristics of a motor. The zero point of the current is shifted backwards; therefore, it tends to speed up the machine, this speeding-up tendency varying with the load.

Obviously, as this effect is a function of the armature current, it should be corrected by means of the armature current. This is readily accomplished by adding to the main field winding a small winding in series with the armature, and connected to magnetize in the same direction as the shunt winding on the field poles. The ampere-turns in this compensating winding are normally small, being just sufficient to balance the effect of the excess short-circuit current in the commutated armature coils. In adjustable-speed machines, at low speed and full field strength, this small compensating winding has little effect, as it is so small in proportion to the shunt ampere-turns. At the highest speeds, however, where the shunt ampere-turns are low and the rise in the speed curve is likely to be greatest, this compensating winding has the greatest effect. Hence, it tends to produce proper compensation at all speeds and loads.

PITTING

Another phenomenon in direct-current machines, which often has been falsely credited to commutating conditions, is that of "pitting," or "eating away" of the mica between commutator bars. This has also been credited to high voltage between bars, too thin mica, quality of carbon brush, use of lubricants, etc.

Some years ago, the writer and his associates made an extended study of this matter, based upon a large number of cases of actual trouble. The results from machines in actual service were so conflicting that no positive conclusions could be drawn. However, eventually the evidence pointed to oil as one of the fundamental conditions in this trouble. Extended tests were then made to determine the effects of oil on the mica, and the results indicated clearly that those insulations which absorb oil were liable to pit or eat away in time. Apparently where the oil could dissolve out the binding material in the mica, minute particles of carbon or copper would be disseminated through the mica, thus decreasing its resistance locally. Combustion of these particles would usually be noticed as "ring-fire" around the commutator. Ring-fire is almost always due to incandescent carbon particles scraped off the brushes, but is not usually harmful if the mica adjacent to the spark does not burn or deteriorate. Experience shows that the ordinary good grades of mica plate are not affected by such ring-fire, and it is only when foreign conducting particles penetrate into the plate that this burning may gradually eat away the mica. It was found that some binding materials used in building mica plate were more soluble in oil than others, and it was noted that in those plates with soluble binders, the pitting was most pronounced. This led then to one solution of the pitting trouble, namely, the use of what might be designated as insoluble binders in the mica plate, with very tight construction of the commutator, so that oil could not penetrate along the sides of the plate, and with care in preventing oil from getting on the commutator.

VIBRATING BRUSHES

There are a number of mechanical conditions entering into the practical side of commutation. It is important to maintain good contact between the brush face and the commutator in order to keep down losses and burning action. Therefore, if the brushes chatter or vibrate in their holders, or have a rocking action tending to give alternate "heel-and-toe" contact, the operation is likely to be affected thereby.

Vibrating brush holders may result from various causes which do not show up on the manufacturer's test. The machine may be so located that its environments are to blame for vibration. Bad gearing may cause chattering, or the foundations or supports may not be as substantial as on the shop test, so that some small disturbances may be exaggerated and produce vibrations in parts or in the whole machine. Sometimes the brushes may chatter due to lack of lubricant, and this may set the whole brush holder structure into vibration.

Vibration of brushes in their boxes may be due to badly fitted brushes, or, on machines which have long been in operation with heavy currents per brush, the brush boxes may be eaten away inside so that they are not of uniform dimensions. Low resistance shunts on carbon brushes are for the purpose of carrying away the current from the brush by some other path than through the sides of the brush box. However, due to the dragging action of the commutator on the brushes, they are liable to bear rather heavily against one side of the box, especially at the lower edge next to the commutator. Some current will naturally pass to the box, and this in time will tend to burn away the boxes and the carbons. The brush then fits tightly only at the top and is free to vibrate or chatter at the commutator end, which is just the place where such movement should be avoided.

Chattering is not infrequently due to lack of lubrication of the commutator or brushes. When the commutator becomes too dry and has a high polish, a radial, or almost radial brush may vibrate or chatter just as a pencil does when moved along a pane of glass. If the commutator is lubricated with oil to overcome this, care should be taken not to use an excess of oil or the mica may absorb it. Frequently, immediately after oiling, a commutator shows ringfire which is due to combustion of minute particles of carbon and oil over the top of the mica. Sometimes chattering is best overcome by the use of self-lubricating brushes. In undercut commutators, the slots are liable to cause chattering with nonlubricated brushes, giving out a noise of a pitch comparable with the product of the revolutions by the number of commutator bars. As oil lubrication should be used with caution on undercut machines, practice now usually calls for some form of self-lubricating brush, partly or wholly graphite.

In commutating pole machines it is especially important that the brushes should not have any heel-and-toe movement, for when the brush makes contact at one edge or the other, the result is equivalent to rocking the brushes backward or forward, which, as explained before, is particularly objectionable in such machines.

BURNT SPOTS

Burnt or black spots will sometimes develop on the commutator at points removed from each other a distance corresponding to that between holders of the same polarity. This is sometimes very bothersome, and the cause is not always easy to find. Any condition which produces one bad spot may tend to produce similar spots symmetrically displaced around the commutator. When one spot is formed, then when this spot passes under one brush arm, the brush contacts at this arm are naturally poorer and the other brush arms of the same polarity tend to take the load, and the current density in their brushes is correspondingly increased during this short period. If there is any tendency toward high mica, for instance, then the increased current at these points will produce increased burning away of the copper and burnt spots may develop.

SHORT-CIRCUITS

One of the most severe conditions that a direct-current generator can encounter is a dead short-circuit across its terminals, or in the immediate neighborhood of the machine. Few machines outside of those of comparatively small capacity and low voltage, can stand such a short circuit without severe flashing. Tests have shown that moderately large direct-current generators will give, at the moment of short-circuit, from 20 to 30 times full-load current. No ordinary commutating machine can be built to take care of such a current rush, and vicious arcing and flashing generally result. Fortunately, however, the majority of short-circuits occur at some distance from the generator, and in many cases, are made through arcs rather than by direct contact, so that the generators do not get the maximum rush of current.

It might be suggested that quick-acting circuit-breakers would take care of such extreme conditions by opening at the loads for which they are set. But this setting is that at which the tripping mechanism works, and if the current rises rapidly enough, it may be far in excess of the tripping value by the time that the breaker actually opens the circuit. In fact, this is just what happens in the case of a severe short-circuit. Oscillograph tests have shown that the current rush on short-circuit may reach its maximum value in one-fiftieth of a second, or even less, while the ordinary commercial circuit-breakers seldom operate in less than one-tenth of a second.

National Association of Cotton Manufacturers

The ninety-seventh meeting of the National Association of Cotton Manufacturers, held at the Hotel Aspinwall, Lenox, Mass., Sept. 29 to Oct. 1, was attended by 200 to 300 members and guests. President Albert Greene Duncan delivered a masterly address in which he reviewed the general financial and commercial situation and stated that spinning and weaving of cotton cloth was the first industry in America to leave the home for the factory; from small beginnings it has built up an invested capital of at least $843,000,000 and is one of the few industries against which no charges of illegal combination or any of the other wrongs so bitterly complained of have ever been made.

Several valuable papers were presented on the cotton industry from cultivation of the staple to marketing of the finished product. The paper by Albert F. Bemis of Boston on "Textiles on the River Hooghly," India, describing methods of mill construction and operation in India and illustrated by stereopticon views was especially interesting from an engineering as well as manufacturing viewpoint. Francis W. Dean read a paper on "Sources of Power," in which he reviewed the forms of modern prime movers and gave interesting statistics of coal and fuel oil production.

The meeting was closed by a banquet at which Hon. W. P. G. Harding of the Federal Reserve Board, Washington, D. C., delivered an address upon "Cotton as a National Asset."

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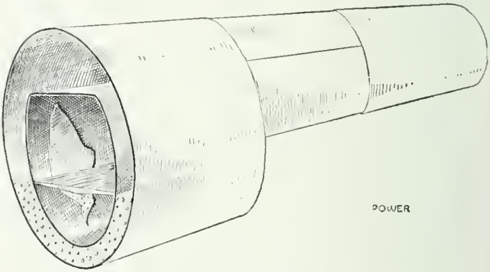
An Explosion Not Mysterious

On Aug. 19, the locomotive type boiler of a portable engine exploded at a shingle mill near Grampian, Penn., causing the loss of two lives. There is some doubt about the age of the boiler; it was between 20 and 30 years old, however. An examination after the explosion showed that the water bottom and water legs had at some previous time been filled with concrete, probably to stop leaks, to the level of the grates. The boiler was hired for temporary use and it is likely that it was not known to be loaded. As a matter of precaution, the pressure had lately been reduced from 120 to 90 lb., because of continual signs of distress.



Water Legs Filled to Grate Level

There were no indications on the crown sheet of low water. There were, however, upward of 50 defects in the firebox alone which would justify an inspector condemning the boiler. As there is no compulsory inspection law in this state, nothing can prevent anyone selling or using such a boiler.

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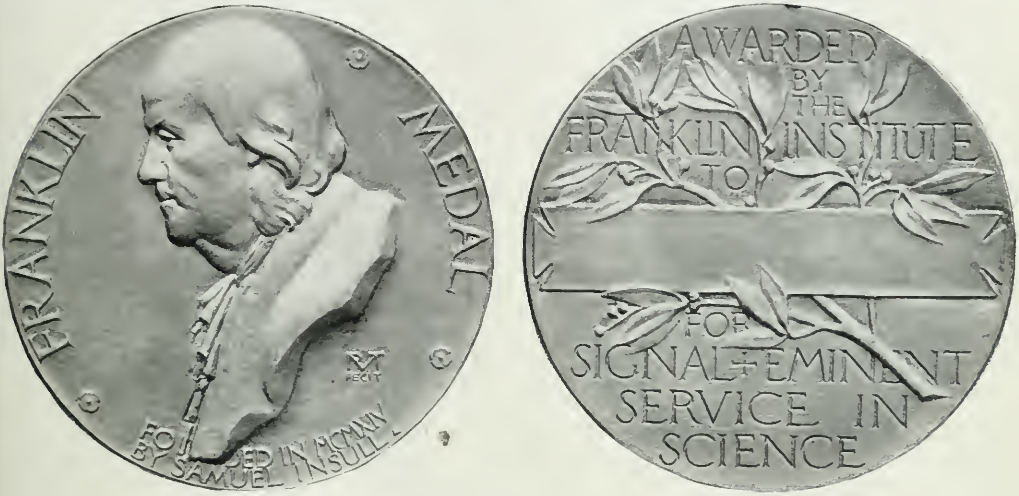
Southern Power Plants Merge

Street railway and power companies throughout middle and east Tennessee have been brought into close affiliation as a result of the formation of a holding company which has taken over the Clark interests for the purpose of promoting economical administration. The company is known as the Tennessee Railway, Light & Power Co. It holds a majority of the stock of the Nashville Railway & Light Co., the Tennessee Power Co., which owns the Ocoee River power plant; the Chattanooga Railroad & Light Co., and companies at Sparta, Cleveland and a number of other towns in Tennessee. It does not control the street railroad company at Knoxville, but supplies current to it and to the city of Knoxville.

It is also learned from an authoritative source that the Clark interests have entered into a contract with the Brady interests, which own and operate the mammoth power plant at Hale's Bar, on the Tennessee River, for the purchase of current.

The Franklin Medal

In December of 1913, President Samuel Insull, of the Commonwealth Edison Co., Chicago, stated that he had been informed that the board of managers of the Franklin Institute of Pennsylvania desired to found the Franklin Medal. The purpose was to award it in recognition of individual contributions to science or to the application of physical science to industry.


FRANKLIN MEDAL
RTM FECIT
FOUNDED IN MCMXIV BY SAMUEL INSULL
AWARDED BY THE FRANKLIN INSTITUTE TO
FOR SIGNAL+EMINENT SERVICE IN SCIENCE

Obverse

Reverse

THE FRANKLIN MEDAL

Founded Jan. 1, 1914, by Samuel Insull

In March of this year Mr. Insull and the board of managers having mutually fixed upon the conditions attending the award of the Franklin Medal, Mr. Insull forwarded his check for $6000. This money has been so invested that the income will enable the board from time to time to strike off and award medals to those who have, in the estimation of the institute, earned them by their work in physical science or technology.

As is indicated by the illustrations, the medal is beautifully modeled, the design having been made by R. Tait McKenzie; the medallion of Franklin is taken from Sully's portrait, in the possession of the institute. Its intrinsic value is about $75.

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Atlantic G. & E. Co. Files Bankruptcy Plea

Liabilities of $2,178,212 were given in a voluntary petition in bankruptcy filed in the United States District Court on Oct. 29 by the Atlantic Gas & Electric Co., 25 Broad St., New York City. The actual value of the assets is not known, but their face value is estimated at more than $5,000,000. The assets include materials and supplies valued at $20,000 in the possession of the Pennsylvania Utilities Co., Easton, Pa., one of the bankrupt company's subsidiaries. They also include bond and note claims against the subsidiary companies amounting to $5,238,710. The company also holds stocks and bonds of the subsidiary companies worth $1,113,817, and $460,500 worth of its own stocks and bonds. It controls the following properties: The Eastern Pennsylvania Power Co. of New Jersey, the Easton Gas Works, the Interurban Gas Co., the Pennsylvania Utilities Co., the Binghamton Light, Heat & Power Co., the Sayre Electric Co., the Jersey Corporation, the Chemung Land Co.

Of the liabilities $2,120,852 are unsecured and there is owed $550 in salaries and $28,286 to its subsidiaries. The company has two outstanding bond issues aggregating $3,815,551, secured by a mortgage to the Atlantic Trust Co., Boston.

Among the stocks and bonds of the subsidiary companies which the parent concern includes in its assets are $2,217,200 of the securities of the Pennsylvania Utilities Co.

The Atlantic Gas & Electric Co. was incorporated under the laws of Connecticut on April 2, 1912, for the purpose of acquiring control of established gas and electric properties through the securities of the companies holding them, and to provide through its working capital independent banking facilities for improvements, extensions and betterments for those properties and to operate them.

The authorized capital stock comprises $5,000,000 six per cent. cumulative preferred and $7,500,000 common. Of these amounts $1,561,900 preferred and $3,361,400 common were outstanding on Dec. 31, 1913. The officers are Arthur D. Lord, president, New York; Carl M. Pihl, vice-president, Easton, Penn.; F. V. Shannon, treasurer, and A. B. Cheadle, secretary.

⁂

Boiler Explosion at Storrs, Utah

On Sept. 28, about 8 o'clock a.m., a boiler explosion of unusual violence occurred at the mines of the Spring Cañon Coal Co., Storrs, Utah, 115 miles east of Salt Lake City. Two men were killed outright and five others were seriously injured. The boiler was of the Continental marine type built by the Springfield Boiler Works less than two years ago.

It appears that the furnace had been overheated, probably due to low water, and the upper side had sagged about 4 in. at a point 5 ft. from the fire door. Repairs had been made and after a satisfactory hydrostatic test on Sunday, the boiler was prepared for duty Monday morning. As the steam approached the working pressure, which was 150 lb., but before the boiler was "cut in," the master mechanic (one of those killed) ordered the fireman to pull the fire as the boiler showed signs of distress. Before the pressure could be reduced the boiler exploded and was hurled through the roof to the hillside 100 yards distant.

The stone walls of the boiler house, which were over 2 ft. thick, were demolished at the front and rear of the wrecked boiler, although the other boilers of the battery, two on each side, were uninjured. The damage will amount to upward of $20,000.

⁂

ERRATA—On page 396, Sept. 15, the third paragraph should read: Before paragraph 10—All staybolts shall be drilled, both from the outside and inside ends, to a depth of not less than one-half inch ($\frac{1}{2}$ in.) inside the boiler plate, and their diameter shall be **not less than** three-sixteenths of an inch (in.) and,

Before paragraph 41—All boilers and parts of boilers shall be securely riveted, not bolted.

BOOKS RECEIVED

OIL FUEL. By Edward Butler. J. B. Lippincott Co., Philadelphia, Penn. Third edition. Cloth: 328 pp., 5¼x8 in.; 145 illustrations: tables.

MECHANICS AND HEAT. By William B Anderson. McGraw-Hill Book Co., Inc., New York. Cloth: 349 pp., 6x9 in., 153 illustrations. Price $2.

PRACTICAL MATHEMATICS FOR ENGINEERS. By F. Hovenden. D. Van Nostrand Co., New York. Cloth; 144 pages, 5x7½ in.; illustrated. Price, $1.

SCIENCE AND PRACTICE OF MANAGEMENT. By A. Hamilton Church. The Engineering Magazine Co., New York. Cloth: 535 pages, 5x7½ in. Price, $2.

MECHANICS FOR MARINE ENGINEERS. By A. N. Somerscales. D. Van Nostrand Co., New York. Cloth; 277 pages, 4¾x7¼ in.; 149 illustrations. Price, $1.50.

FUEL. GASEOUS, LIQUID AND SOLID. By J. H. Coste and E. R. Andrews. J. B. Lippincott Co., Philadelphia, Penn. Cloth; 278 pp., 5¼x7¾ in.; 63 illustrations; tables.

HIGH-POWER GAS ENGINES. By H Dubbel. D Van Nostrand Co., New York. Cloth; 197 pages, 7½x11 in.; 423 illustrations; 13 folding plates. Price, $5.

INDICATOR DIAGRAMS FOR MARINE ENGINEERS. By W. C. McGibbon. D. Van Nostrand Co., New York. Cloth; 182 pages, 7¼x9¾ in.; 197 illustrations; tables. Price, $3.

HANDBOOK OF TABLES AND FORMULAS FOR ENGINEERS. By Clarence A. Peirce and Walter B. Carver Leather; 168 pp., 4x7 in.; illustrated; tables. Price, $1.50.

SIMPLE PROBLEMS IN MARINE ENGINEERING DESIGN. By J. W. M. Sothern and R. M. Sothern. D. Van Nostrand Co., New York. Third edition; cloth; 191 pages, 5x7¾ in.; tables. Price, $1.

ELEMENTARY MATHEMATICS FOR MARINE ENGINEERS By J. W. M. Sothern and R. M. Sothern. D. Van Nostrand Co., New York. Cloth; 174 pages, 5x7¾ in.; illustrated, tables. Price, $1.

MARINE ENGINEERING RULES AND TABLES By A E. Seaton and H. M. Rounthwaite. D. Van Nostrand Co., New York. Twelfth edition; leather; 713 pages, 4x6½ in.; illustrated; tables. Price, $3.50

"VERBAL" NOTES AND SKETCHES FOR MARINE ENGINEERS. By J. W M. Sothern. D. Van Nostrand Co., New York. Eighth edition; cloth; 676 pages, 6x9½ in.; 545 illustrations; 10 folding plates; tables. Price, $5.

ENGINEERING AFFAIRS

Public Lectures in New York City—The department of education of the City of New York, under the supervision of Henry M. Leipziger, offers a number of lectures for this fall and winter of interest to electrical men. Among the subjects are "Wonders of Electrical Inventions," "Principles and Practice in Electrical Engineering," "Electricity and Magnetism." These lectures will be given in the city's public school halls and the dates and names of the lecturers have been prominently posted.

Evening School of Engineering at University of Pittsburgh—The Evening School of Engineering giving graduate courses will be a new feature at the University of Pittsburgh this autumn. It is the first time this kind of work has been attempted in this country, although several day schools offer graduate work.

In the Pittsburgh district there are more engineering graduates than in any equal district in the United States. It is for this reason that the university will provide for men who do engineering work during the day an opportunity to study engineering in the evening. Men who are properly prepared and who have received their bachelor of science degree may obtain an engineering degree from the University of Pittsburgh.

Many young engineers find after engaging in practical work that the courses which they took in college did not fully prepare them for their duties. Few have opportunity to quit work and go back to their own college for further study, but many can devote their evenings to new courses.

Courses will be offered in the valuation of public utilities, mechanical, civil, electrical, sanitary, mechanical, railway, concrete engineering, etc. The faculty will include some of the best engineers in the Pittsburgh district.

The New York School of Heating and Ventilating Class will meet Monday evening of each week at 7:30 o'clock in room 511, World Bldg., Park Row, New York, under the direction of Charles A. Fuller, consulting engineer with Messrs. Clark, MacMullen & Riley. Mr. Fuller has been engaged for a number of years in the design and supervision of heating and ventilating work for all classes of buildings, is a graduate of the University of Michigan, and has had successful experience as instructor in mechanical engineering at the University of Pennsylvania. He is, therefore, well fitted to offer the best instruction in the most recent practice.

The course consists of 22 lectures covering the subjects of heating and ventilating with special reference to computation of heating surfaces, pipe sizes, boilers, etc., for gravity and vacuum steam systems; for gravity and forced hot water systems; sizes of ducts, fans and heaters for various kinds of ventilating systems; purification of air and humidifying devices. No particular requirements as to education and mathematics are necessary as the various subjects are handled in such a manner as to eliminate the more difficult mathematical calculations.

The fee for the complete course will be $10, payable in advance. The first meeting will be held on Nov. 2. All who wish to join the class should be on hand promptly at that time.

PERSONALS

Walter B. Snow, publicity engineer, has removed his offices to rooms 511-516, in the new Federal St. building, 136 Federal St., Boston, Mass. This organization, built up during the past seven years, will be better equipped to act as publicity managers and general advertising agents.

Martin R. Carpenter, refrigerating engineer, has opened an office in Cincinnati, Ohio, where he will make a specialty of ice and cold-storage plants and consultation work along refrigeration lines. Mr. Carpenter was with the Triumph Ice Machine Co. for eight years, four of which he was its chief engineer.

Thomas Hawksworth has been appointed chief engineer at the Brilliant pumping station, Pittsburgh, Penn. He succeeds H. E. Fernald, who resigned because he is removing to Maine, where he has important business interests. Mr. Hawksworth has been an assistant engineer at the pumping station about 12 years.

Frederick R. Hutton, consulting engineer of the Automobile Club of America, will address the joint meeting of the Engineers' Club of Cincinnati, and the Cincinnati Section, A. S. M. E., Oct. 15, at 8 p.m., in the Literary Club Auditorium. The address will be on the subject, "The Testing of the Motor-Vehicle Engine," and illustrated with stereopticon views. Mr. Hutton was honorary secretary of the American Society of Mechanical Engineers, 1883-1906, president of the society, 1907, and is now emeritus professor of mechanical engineering, Columbia University.

*

STATEMENT OF THE OWNERSHIP, MANAGEMENT CIRCULATION, ETC., OCT. 1, 1914,

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The balance of the stock issued (less than 1% each) is owned by 70 employees, 3 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities: Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

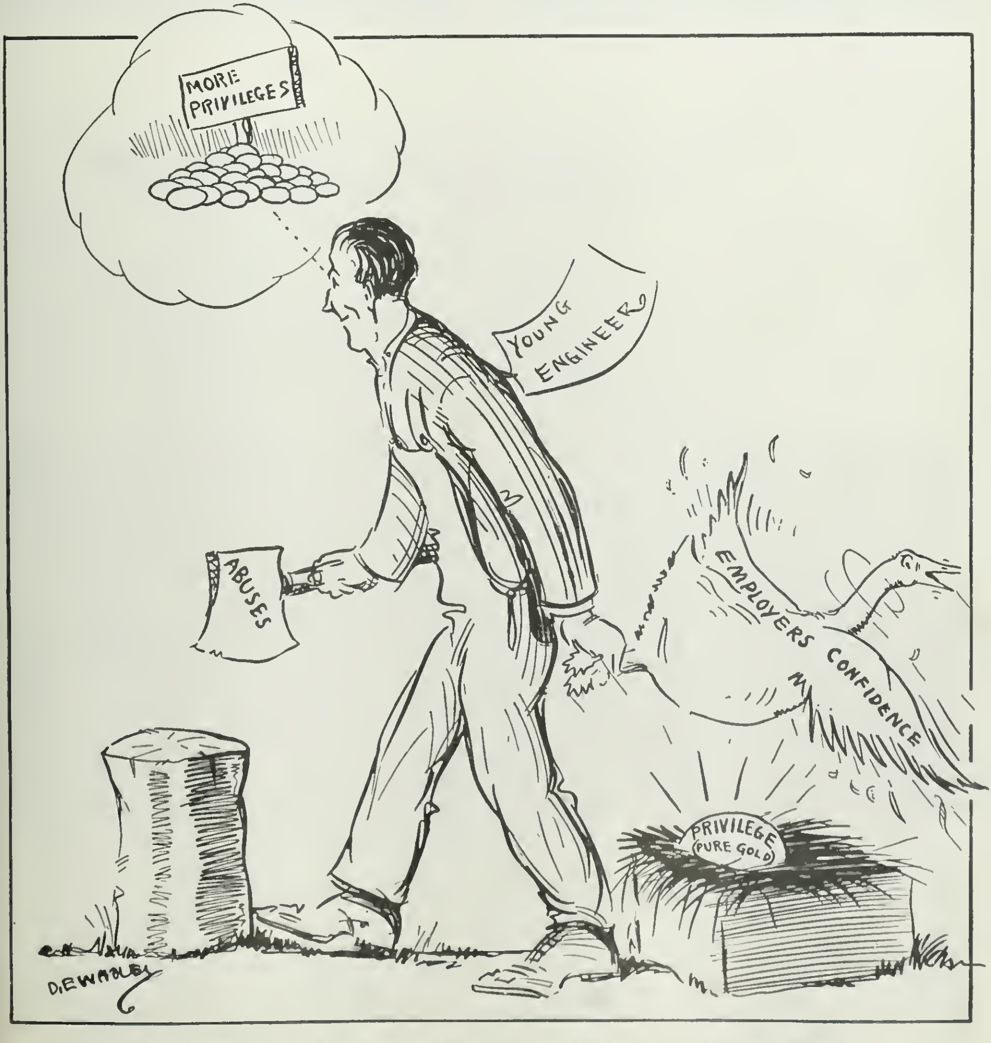
C. W. Dibble, Vice-President.
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 30th day of September, 1914.

RICHARD L. MURPHY,
Notary Public,
(My commission expires March 30, 1915.)

POWER

Vol. 40 NEW YORK, OCTOBER 20, 1914 No. 16



Killing the Goose That Laid the Golden Egg

Adelaide Municipal Tramway Power Plant

By F. G. Moffitt

SYNOPSIS—The plant consists of three 1500-kw., 11,000-volt turbo-generators carrying self-contained exciters. To prevent rushes of over-superheated steam, special thermo buffers have been erected. There is also a superheat alarm when the steam temperature approaches a dangerous limit. The six 1000-hp. boilers operate at 200 lb. pressure. The furnaces are equipped with chain-grate stokers.

⁂

The power plant of the Adelaide Electric Tramway, at Port Adelaide, South Australia, is designed to generate electrical energy at 11,000 volts and to transmit it by a duplicate overhead transmission line to two converter stations, a distance of about ten miles. Eight miles of this line will be overhead work and two miles will consist of underground cables. Five miles from the station a junction line connects with No. 2 converter station, which is three miles distant.

The site of the power house has been chosen with a view to the most economical coal-handling arrangement, and also for securing an ample supply of condensing water from the river.

During the work of excavation for the foundation, more than 600 piles were driven to the limestone bed 30 ft. below the ground level, and 27 ft. below the high-water mark, for the purpose of securing sound foundations for the heavy machinery to be installed. The preliminary work was particularly difficult, owing to the subsoil of soft mud and quicksand.

Turbines

In the turbine room, Fig. 1, there are three 1500-kw., three-phase, 11,000-volt turbo-generator sets, each having a 95 per cent. power factor, and guaranteed to give a 25 per cent. overload for two hours. The speed of each is 1500 r.p.m.

Each alternator carries a self-contained exciter, fitted with a compensating winding, which automatically adjusts the 100-volt exciting current at any load.

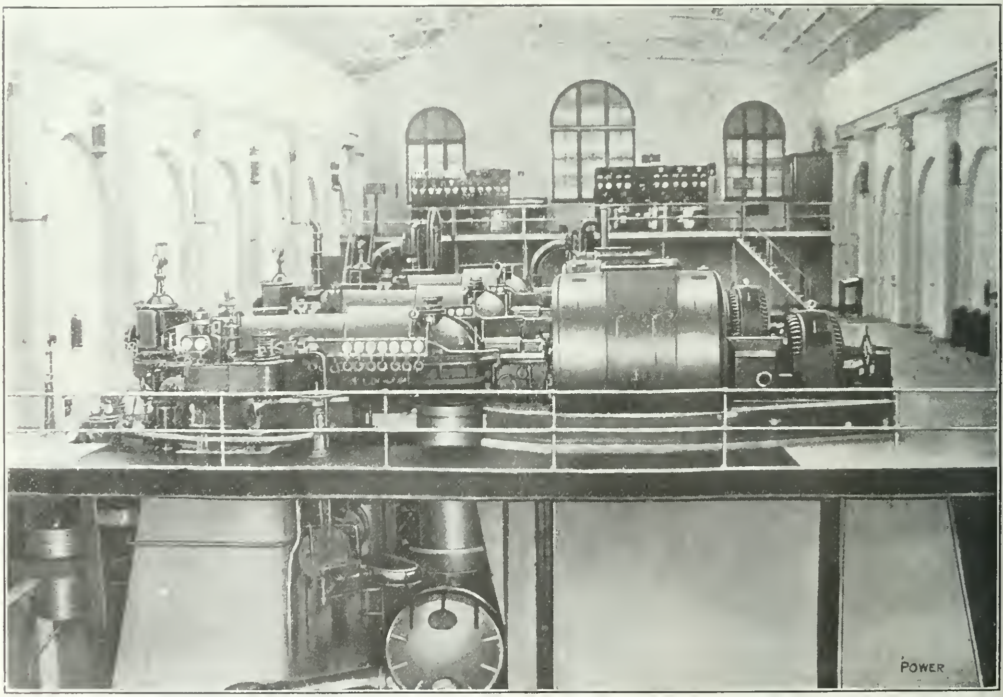


Fig. 1. Turbine Room of the Adelaide Municipal Power Plant

In the basement, under the turbines, are the main condensers and air pumps. The circulating cooling water, brought from the Adelaide River for the condensers, is returned through an outlet conduit, and discharges into the river 300 ft. from the inlet conduit. The cooling water is supplied by an electrically driven centrifugal pump which draws the water from the conduit below the engine-room floor.

To prevent sudden rushes of over-superheated steam

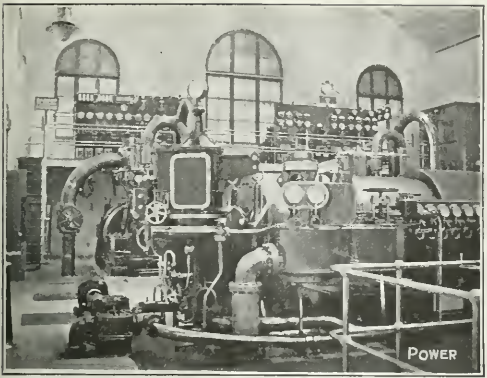


FIG. 2. STEAM END OF TURBINE AND THE ENGINE-DRIVEN SET

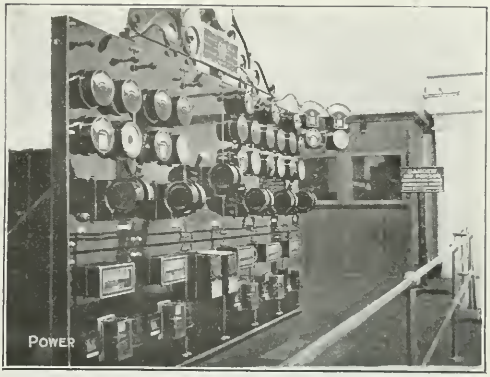


FIG. 3. ALTERNATING-CURRENT SWITCHBOARD

into the turbine, special thermo buffers have been erected. In addition, there is a superheat alarm which operates when the steam temperature approaches a dangerous limit.

The lubrication of the turbine is a special feature, the cooling oil being pumped from a well under the turbine, and after passing through the bearings at about 6 lb. pressure it is returned to the well after passing through a cooling chamber.

All auxiliaries are driven by direct-current motors at 200 volts supplied by a 200-hp. unit, Fig. 2, which also supplies energy for station lighting. The alternating-current switchboard, Fig. 3, is foolproof, the live parts being covered with armor plate and inaccessible to all except the electrician on duty. The main switches are of the oil-brake type, relays being fitted to the transmission lines and arranged to throw out the oil switches in case of trouble on the line.

BOILERS

There are six 1000-hp. water-tube boilers, Fig. 1, the largest of their kind in Australia. Each furnace is fitted with twin automatic chain-grate stokers with a ratio of 1 to 50 of heating surface. Superheater tubes raise the temperature of the steam to 630 deg. F., with a working pressure of 200 lb. per sq.in. There are 216 tubes in each boiler and 104 superheater tubes. By special arrangement, the temperature of the steam may be

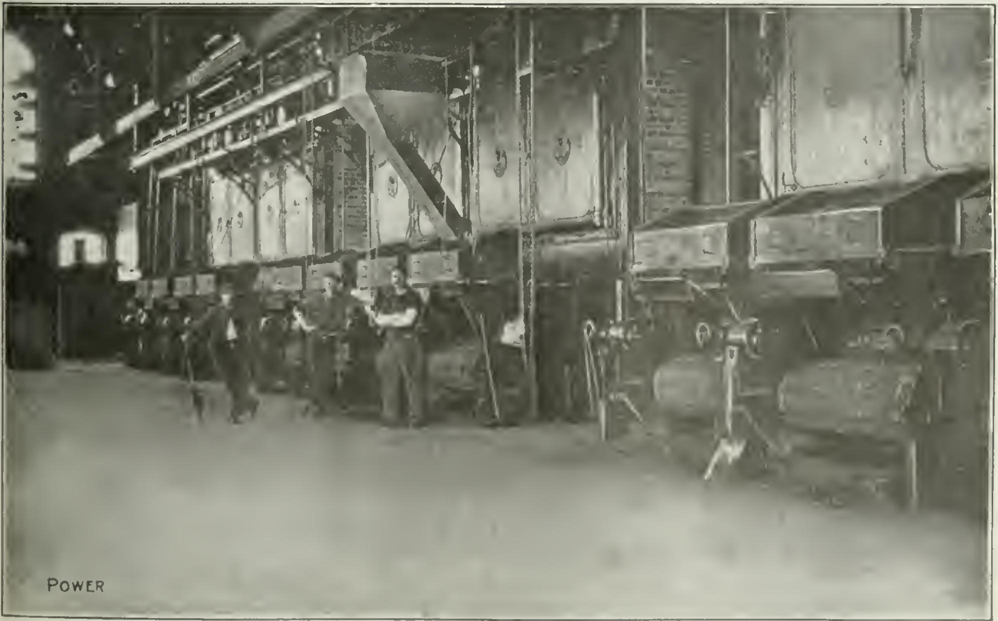


FIG. 1. BOILER ROOM, SHOWING CONVEYOR AND WEIGHING SCALE

regulated from the engine room to suit the requirements. The hot gases which are driven off from the fires are deflected by special dampers into the economizer chambers at the back of the boilers. The economizers are arranged in three groups, with 222 tubes in each and heat the feed water to a temperature of 300 deg. F. before it enters the boilers.

The stokers are chain driven from a shaft running the length of the boiler house and situated in the ash runway. There are three speeds and a neutral which allows the stokers to travel at from 1 to 8 ft. per hour. Should any of this gear get out of order, a patent release clutch is introduced, which throws the grate out of action.

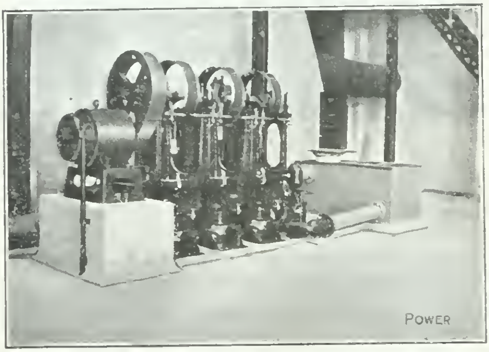


Fig. 5. Feed-Water Pump and Lea Recorder

Each boiler is fitted with two 6x6-ft. steam drums, lying across the two main drums. One is connected to the saturated steam and the other to the superheated steam pipe; the main take-off pipe is fitted between them with a butterfly valve, so that if the superheated steam rises too high this valve may be opened to admit saturated steam, thus keeping the steam down to the required temperature.

Piping

Feed water is delivered from the main water supply into a 4000-gal. tank through a valve operated by a float. From this tank it flows into a makeup tank and then goes through a softener to the hotwell, where it is pumped to a feed-water heater, then to the economizers, and into the boilers. All makeup water is metered by a recording meter. Fig. 5.

The main steam line is next to the engine-room wall, and from one end of it a pipe containing a reducing valve which reduces the pressure to 100 lb. runs to the auxiliary steam units. The main supplies to the turbine are tapped off from the main steam line and go through the wall below the engine-room floor, the supply being controlled by a main stop valve close to each turbine. On the main steam line a recording thermometer is installed which leads to the engine room, and if the steam raises too high an alarm is sounded, denoting which boiler is above normal in temperature. There are two main boiler feed pumps placed side by side at the west end of the boiler room and adjacent to the hotwell from which the water is drawn. Next to the feed pump is the feed-water heater, which uses exhaust steam from the 250-hp. engines.

Fuel is brought into the yard and dumped into a hopper, from which it gravitates through crushers, driven by a 20-hp., compound-wound, 200-volt motor, into a 100-ft. bucket conveyor. Each bucket holds about 80 lb. of coal, and it requires eight minutes to make one revolution. The conveyor is driven by an 8-hp. motor. The coal is conveyed to the storage bunkers above the boiler house, each bunker having a capacity of 1400 tons. From the bunkers the coal is drawn off and automatically weighed by a traveling weighing machine. The fuel then falls through a chute into a small hopper above the stokers, from whence it goes to the grates and is fed to the furnace as required. The capacity of the bucket is 40 tons per hour. The bunkers are so arranged that there is a separate one for each boiler. The special weighing machine below the bunker is electrically operated and passes from boiler to boiler as required.

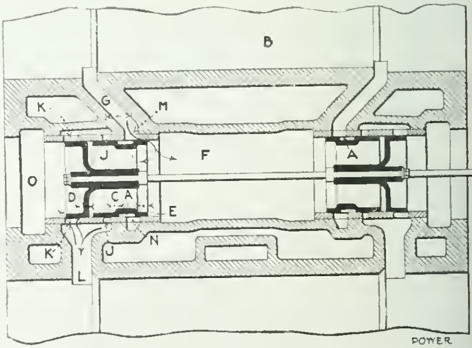
Ashes

The ashes are disposed of by opening a trap at the back end of the grate, where they drop into a hopper in the ash runway and are removed at the end of each shift.

Furnace gases go to a steel stack of the self-supporting type. It is 200 ft. high and 24 ft. outside diameter at the bottom, and is bell-shaped for 50 ft., then straightens the remaining 150 ft. with an inside diameter of 12 ft. The draft on a normal day is 1 in. This steel stack is one of the largest in Australia.

Wolf Piston Distributing Valve

A recent patent granted to Rudolph Wolf, Magdeburg-Buckau, Germany, is for a piston distributing valve for compound engines arranged to work in common to the high- and low-pressure cylinders. The valve has channel-shaped passages through it for distributing the exhaust steam from the high-pressure and the admission of steam to the low-pressure cylinder.



Wolf Piston Distributing Valve

The accompanying illustration shows a section through a distributing valve designed with an annular recess *A*, which remains in communication with the high-pressure cylinder *B* and allows the exhaust steam to pass directly from it to the low-pressure cylinder when the valve in moving from its middle position has traveled through the distance *C*, corresponding with the lap *D* for the remaining opening of the valve.

After the valve has moved from its middle position through the distance E, the supply of steam is admitted from the high-pressure cylinder B into the receiver F, through the passage G, as indicated by the arrow. The admission of steam into the low-pressure cylinder H begins through the ports J and K and through the port L, as indicated by the arrow, after the valve has moved from its middle position through the distance C.

The advantage consists in a diminution of the distance M between the steam outlet port N of the high-pressure cylinder B and the steam inlet port J to the low-pressure cylinder H, and in a reduction of the number of places to be kept steam-tight. There is also a reduction in the losses of pressure and heat during the period steam is supplied to the low-pressure cylinder, as a greater part of the working steam not passing through the receiver goes from the high- to the low-pressure cylinder.

Because of this the advantage of the Wolf engine with respect to the steam supply by the shortest way is had, while the disadvantage—the interdependence of the steam distribution in the high- and low-pressure cylinders—is avoided. This is owing to the choice of varying laps and that the steam in passing through the receiver is given an independent exhaust from the high-pressure and an independent admission into the low-pressure cylinder.

* *

Will Quizz, Jr.

SYNOPSIS—Chief Teller is reminded of a promise to tell about the mechanical equivalent of heat and explains the subject in an elementary way.

*

"Chief, you promised to tell me about the relation of heat to mechanical energy; how about it?"

"Will, heat is just work—through and through. It can't keep from work. In fact, as soon as heat is liberated from the coal it gets busy at once—and works! Get that! It heats air and all the material near-by, but we are most interested in its action on the water in the boiler. The first action is that it makes each molecule more energetic. While these molecules do not change form (from water to steam) at once, they vibrate against each other more and more rapidly as heat is applied.

"In fact, Will, the wise ones say that everything solid, liquid or gas is made up of molecules, which are always in motion so long as they contain any heat at all (above absolute zero). Of course, this motion is not perceptible, but it has been proved by a process of reasoning by the scientific fellows. The molecule itself is the smallest bit of a thing which has been broken all to smithereens!

"Pretty small sample, Chief!"

"Yes, but the wise ones know. Anyway, suppose each particle of water to be separated to itself. As it became heated it would expand and require more room, and in order to get it, it would have to push some of its next neighbors away. What is that action?"

"Why, that's work, isn't it?"

"That's right. As the water expands it is lighter for the space it occupies, and it rises toward the surface, where it has less pressure about it, but it still has the air pressure (14.7 lb.) Other particles in turn get heated and act the same way until they have absorbed enough heat energy to overcome the air pressure. Then they will change their form from water and become steam. Each molecule must expand against the pressure of the air, and as the total surface exposed to the air pressure becomes greater, it means more work, which requires more heat.

"When it gets to be steam, the molecule is nearly 1700 times larger than when it was water, and in expanding so much there has been a lot of work done. The quantity of this heat energy used depends on the amount of external force (pressure) it has to overcome—that it has to push back and the distance—to make room for itself. It is our old acquaintance *foot-pounds* again. If it has the atmospheric pressure only to work against, it requires a certain amount of heat energy, but as the pressure increases, it has to have more heat energy because of the greater work it has to do.

"We know that if we burn coal under the boiler and make steam, which is used in the engine; that is, converting heat into energy in the ordinary way. But along in 1840 to 1849 an Englishman, Doctor Joule, proved that heat was not a material substance, as was then commonly believed, but *energy* which could be applied to, or taken away from, bodies. So he got busy and devised a means to determine the mechanical equivalent of heat; that is, how many foot-pounds of energy there were in one B.t.u., or how many B.t.u. in a given number of foot-pounds."

"That was some stunt, Chief. How did Joule do that?"

"One rig he used was a copper cylinder having fixed baffles or vanes inside and a vertical shaft in the center, with paddles attached to rotate between the baffles.

"With water in the cylinder there would be considerable resistance. He wound a cord around a spool on the upper end of the shaft, passed the end over a pulley and attached a weight to it so that the weight in lowering would rotate the shaft and paddles; this would absorb power in agitating the water, which in turn caused the water to heat.

"Joule then put into the cylinder 1 lb. of water which was at the temperature of 39 deg. F. Then he put on a weight and wound it up to a certain point—and let 'er go. When the weight had lowered to a certain mark, the thermometer in the water showed that its temperature had increased 1 deg. He next got busy with a stub of a pencil and multiplied the weight in pounds by the number of feet the weight had lowered—foot-pounds of work required to produce the 1 deg. change in temperature. He verified this in a great many different experiments and established what is known as Joule's law of the mechanical equivalent of heat.

"Later, experiments with more refined apparatus showed that Joule's figures were probably a little low and now 778 foot-pounds is accepted as the mechanical equivalent of 1 B.t.u. The other way round, each B.t.u. should produce 778 foot-pounds of work, which would be the case if none went astray in the process of transfer. But they certainly do get lost in the shuffle.

"So you see, Will, there is nothing very difficult to understand about the mechanical equivalent of heat."

The Unaflow Engine in Europe

By A. D. Skinner*

The American engineer who travels Europe, not as a sight-seeing tourist but with a view to studying engineering practices, is frankly dumbfounded when he realizes how far in advance of his native country the Europeans are in respect to power-plant engineering and efficiency. The mediæval may exist in their castles and old ruins, but not in their power-plant equipment.

This superiority exists not because there are better engineering brains in Europe than in America, but because they have no cheap fuel. Necessity has forced them to conserve their natural resources, of which fuel is the most valuable; and competition in the building of prime movers has developed the fact that it does not cost very much more to install a plant that develops a brake-horsepower-hour on 8 or 9 lb. of steam than to build one that uses twice or three times that amount.

It is one thing to demand an economical plant but quite another to make sure that you have it. Therefore, nearly every steam engine installed in England and on the Continent is tested for economy by the purchaser after he has operated it a few months, and before he has made final payment.

The maintenance of economy is often assured by having the plant tested every few years. The result is that engine builders fight over a difference of a few grams in their economy guaranties. Several engine builders, both in England and on the Continent, informed the author that only in exceptional cases did the purchaser accept an engine without making an economy test.

Maintenance of high economy rather than first cost is therefore the factor that decides the selection of prime movers.

Germany seems to have taken the lead in the development of power-plant efficiency. That they have been working along these lines for years is exemplified in the power plant of the Wertheim store in Berlin, where the engines installed 14 years ago are still delivering a kilowatt-hour on less than 3 lb. of coal.

The development of the power-plant industry in Germany has been truly wonderful; and, without statistics at hand, the author feels safe in saying that Germany is building a greater horsepower of engines than the United States. Of the many engine factories visited, the smallest employed 700 men, while several had from 1400 to 2000 men on their pay-rolls.

This large output of engines requires a corresponding output of electrical machinery; and Germany has two electrical concerns, each larger than the largest electrical manufacturing company in this country. One employs 79,000 men, and the other 83,000. Their combined annual output is valued at $197,000,000.

Where do all these engines go? On account of the steady industrial growth of Germany, a great many do not go outside of the confines of the empire. The power companies, which are for the most part municipally owned, and almost without exception profitably operated, are not permitted to make discriminatory rates in favor of the large consumer which force the helpless small consumer to pay for the resultant loss. The result is that the small consumer gets his current at less than half the charge made in the United States, the large consumer makes his own power, and the publicly owned power companies are making money.

The power equipment not used at home is exported to all parts of the globe. As every American engine builder knows to his sorrow, the Germans have taken from him practically all his export trade in South America, China, Japan, Russia and Africa, largely because they build a more economical engine.

People who installed power plants 14 years ago, which still develop a kilowatt-hour on less than 3 lb. of a rather poor grade of coal, would probably not be content with even this remarkable achievement; and it is therefore interesting to learn what they have been doing since that time.

They have developed a single-cylinder engine with two inlet valves, and no exhaust valves—unless the piston may be called such—which gives as good economy as a triple-expansion engine with 12 valves, together with the consequent complicated gearing.

Moreover, this engine uses practically no more steam per indicated horsepower-hour at one-fourth load than at full load, making it unequaled for variable loads.

A test on an 18x20-in. Unaflow engine, by Prof. Bache, of the Technical High School of Copenhagen, in 1910, showed a steam consumption per i.hp. per hour of 9.0, 9.3, 9.5 and 9.7 lb., with the respective loads of 116, 149, 184 and 222 hp. The engine, of course, was operating condensing and with superheated steam. Tests on a 300-hp. Unaflow engine have shown a steam consumption as low as 8.8 lb. per i.hp. per hour.

The Unaflow engine is no longer an experiment in Germany, but is built by practically all of the leading engine builders. So far over 1,000,000 hp. is in actual operation.

Gebrüder Sulzer have built, at the Ludwigshafen Works, over 60,000 hp. of Unaflow engines, and while the author was in their plant, he was informed that they had orders on their books for 30 Unaflow engines, some as large as 2000 hp.

Ehrhardt & Sehmer, of Saarbrücken, who employ 2000 men in their excellently equipped shops, have built nearly 200,000 hp.; and to them belongs the credit of building the largest Unaflow engine in existence. This engine is of 6000 hp. nominal capacity, and is installed in the plant of Gebrüder Röchling, at Völklingen. It is directly connected to a train of rolls, and is capable of giving an economy of 8.5 lb. of steam per i.hp. per hour.

The load on this engine fluctuates from 0 to 6000 or 7000 hp. every few minutes; and the designing and building of a single-cylinder engine to operate under these severe conditions, and at the same time to give the highest economy under all conditions of load, represents one of the greatest steam-engineering feats ever recorded. On account of its immense size, the engine is very poorly depicted in Fig. 1.

The first locomobile builders who adopted poppet valves and Unaflow cylinders were the Maschinenfabrik Badenia, at Weinheim, who have now built over 1000 poppet-valve Unaflow locomobiles, of a total capacity of 200,000 hp.

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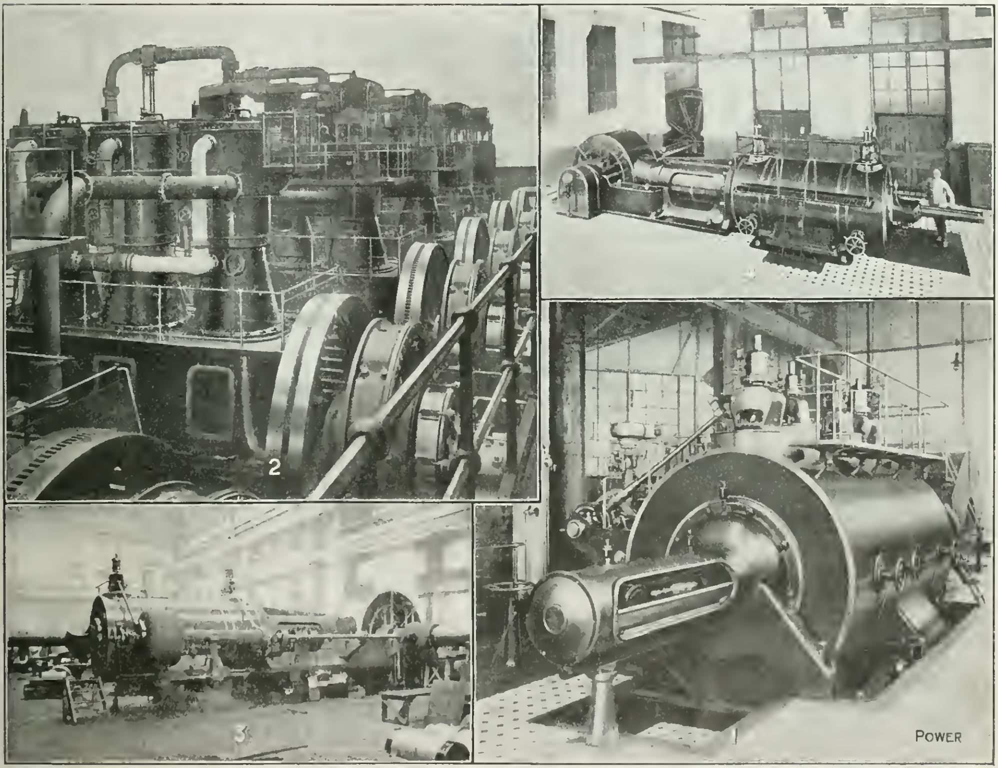
*Vice-president, Skinner Engine Co.

Fifty in different stages of completion were to be seen on the author's visit there.

The adoption of the Unaflow principle for locomobiles in Germany was undoubtedly hastened by the publication in the *Zeitschrift des Vereines Deutscher Ingenieure* of a series of tests, after several years' operation under average operating conditions, on twelve different locomobiles, where the average fuel consumption was found to be 5.92 lb. per kw.-hr., when operating condensing and with superheated steam.



The Unaflow Engine in Europe

Fig. 1. Six thousand horsepower in a single cylinder. Fig. 2. Unaflow engine in foreground replaces steeple compound. Fig. 3. A Sulzer Bros. Unaflow. Fig. 4. Typical German Unaflow installation.

Unaflow steam cylinders are now being extensively used on air compressors in Germany, being ideal for this service on account of the high economy under intermittent loads.

The Prussian Railway has in operation fourteen Unaflow locomotives, and has since purchased sixteen more, after many careful tests, which have demonstrated a saving of nearly 30 per cent. over the counter-flow type.

Unaflow locomotives are now being used extensively by both the Russian and Austrian railways, and England is testing out her first Unaflow locomotive.

The best evidence of German activity is found in the fact that, while the Unaflow principle is old, its practical application to steam engines was not seriously attempted until four years ago*; and, in this short time, the Unaflow has made serious inroads upon the counterflow steam engine.

England was not many months behind Germany in the adoption of the Unaflow engine; and already many thousand horsepower have been built, both for home consumption and for eastern colonies.

Fig. 2 shows an interesting replacement in the plant of the Salford Corporation, where three steeple-compound cylinders on a 1200-hp. engine were replaced with Unaflow cylinders. The original engine consumed 25.25 lb. of steam per kw.-hr., which is equivalent to 15.8 lb. per i.hp.-hr.; while the Unaflow, on test, obtained a steam consumption of 17.45 lb. per kw.-hr., or 10.9 lb. per i.hp.-hr. This was with 150 lb. working pressure, 25 in. vacuum, and only 80 deg. F. superheat. The purchasers expect to replace the compound cylinders of their five remaining engines with Unaflow cylinders.

The American who visits William Jessups & Sons, Ltd., Sheffield, will find that the last engine they installed was a Unaflow; and, if he inspects the municipally owned central-station plant at Sheffield, he will be chagrined to see a 500-kw. compound Corliss engine, of American manufacture, that has not been in operation since they installed a Unaflow engine a short time ago.

One English manufacturer, who builds both steam turbines and Unaflow engines, recommends the latter type for capacities of 750 kw. and less, but states that above these sizes the increased cost of land, building, foundations, etc., due to the installation of the reciprocating engine, more than offsets the gain by reason of better economy.

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*This article was written more than a year ago. There are even more Unaflow engines now than the writer counts.

In Germany and Belgium, however, the reciprocating engine seems to have the preference over the turbine, even in capacities up to 1500 kw. In comparing the Unaflow to the turbine, it should be remembered that practically all the steam plants in Europe are operated condensing, and the noncondensing turbine is nowhere in evidence.

The value of superheat, even for small plants, was realized many years ago, and one will have to go far in Europe to see a modern plant operating with saturated steam; the result being that the Corliss valve was largely superseded by the poppet valve on large stationary engines, and by the expanding piston valve on the locomobiles.

Now that the three largest locomobile builders have adopted the poppet valve, this type of valve is left in undisputed supremacy on the Continent, and is the typical European valve.

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Chain-Grate Settings--II*

By Osborn Monnett†

SYNOPSIS—Typical installations of chain grates under horizontally baffled boilers of different types. Tile-roof furnaces and vertical baffles.

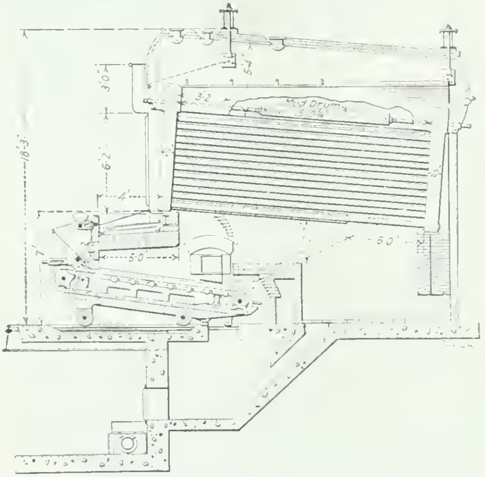

Fig. 1. Murray 300-Hp. Water-Tube Boiler and Green Chain Grate

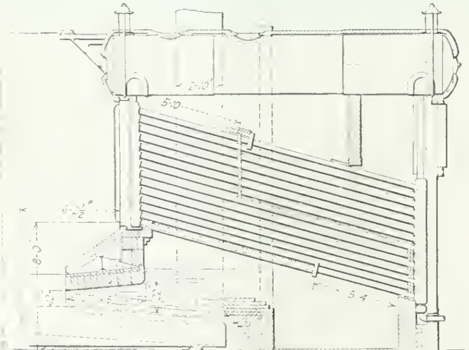

Fig. 2. Laclede-Christy Stoker under 500-Hp. B. & W. Boiler with Sewell Baffle

It is a simple matter to apply the chain grate to the ordinary Heine type setting. The important dimension is the distance from the floor to the bottom of the front header, and for good operating conditions this should generally be not less than 7 ft. 6 in. with a horizontal grate or 7 ft. with an inclined grate. Fig. 1 shows a typical installation consisting of an inclined Green chain grate and a Murray water-tube boiler. As the grate is inclined, the head room for the setting is reduced to

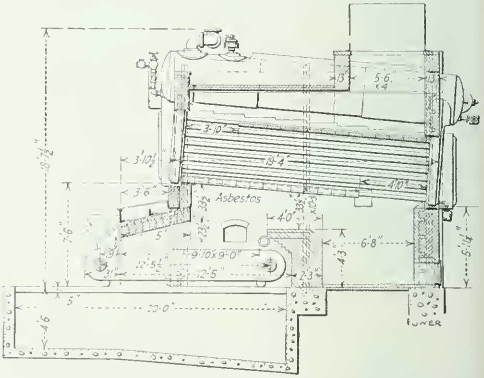

Fig. 3. S. & S. Chain Grate under 463-Hp. Heine Boiler

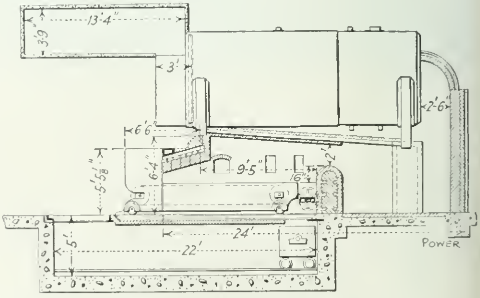

Fig. 4. Lyons 360-Hp. Boiler and McKenzie Chain Grate

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

7 ft. without restricting the area over the bridge-wall, which in all cases should be at least 25 per cent. of the active grate surface. Installations of this kind should never be made flush front, as this arrangement does not give the flame travel required before the gases come in contact with the heating surface. The illustration shows a minimum 5-ft. arch and a 4-ft. extension from the gate to the front header. High-pressure water-backs, such as are shown in this illustration, are considered good practice, as they form a rigid and permanent support for the bridge-wall.

Fig. 2 shows a 500-hp. B. & W. boiler with a Laclede-Christy chain grate having a head room of 8 ft. under the header. With this type of boiler, which has a tube pitch in excess of other horizontal water-tube boilers, 8 ft. is the minimum head room which should be allowed with the horizontal baffle. This obviates the danger of restricting the opening over the bridge-wall and the combustion chamber itself, which would tend to "bottle" the heat, with disastrous effects on the brickwork. This illustration shows the Sewell baffle. With natural draft, it is not advisable in the average case to use this baffle on boilers less than 14 tubes high, as the restriction in the gas passes will reduce the capacity and increase the maintenance cost. This baffle "kills" the pull of the stack and does not allow sufficient draft over the fire to accomplish the desired results. With a 14-tube high or a double-deck boiler, Sewell baffle works out well.

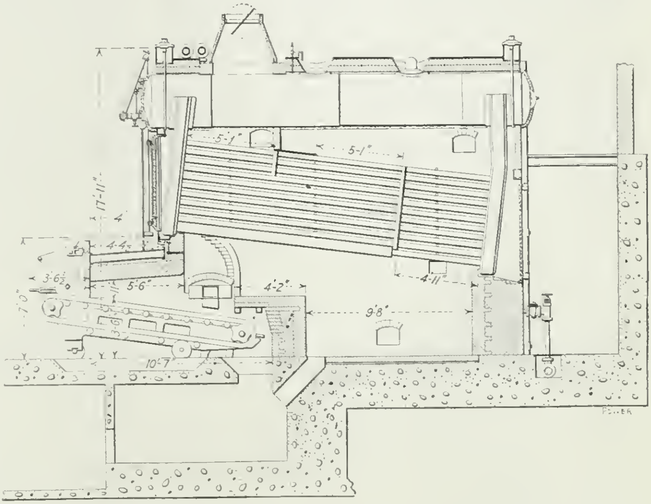

FIG. 7. ERIE CITY BOILER, 326 HP., WITH TWO ROWS OF TUBES BARE FULL LENGTH. LACLEDE-CHRISTY STOKER

Figs. 3 to 6 illustrate horizontally baffled boilers of different types. The head room varies with the type of boiler and the pitch of the tubes. All of the boilers can be installed with the head room for the furnace varying from 7 to 8 ft., the average being about 7 ft. 6 in. for the ordinary installation.

With the long run of baffling forming a tile roof over the combustion chamber, the temperature in some cases becomes so high as to cause an excess maintenance charge for brick work. To relieve this, the expedient shown in Fig. 6 has been adopted with success. In this installation, with a head room of 6 ft. 6 in. under the front header, the box tile on the front end of the lower tubes

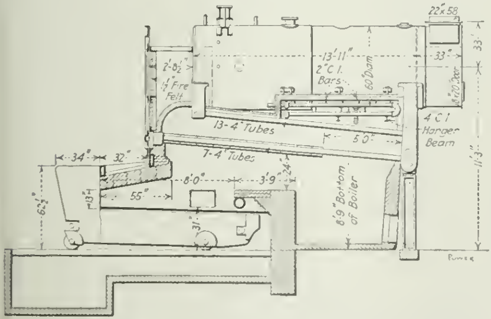

FIG. 5. HAWKES BOILER, 150 HP., WITH SUPERHEATER AND CONTINENTAL CHAIN GRATE

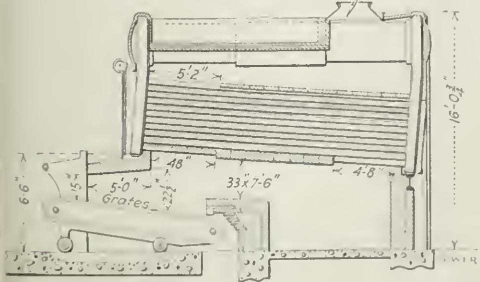

FIG. 6. EDGE MOOR WATER-TUBE BOILER AND GREEN INCLINED CHAIN GRATE

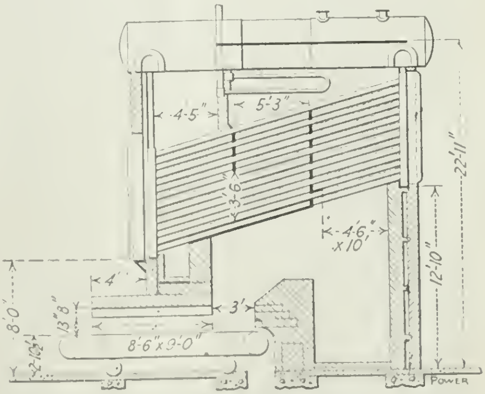

FIG. 8. B. & W. BOILER, 500 HP., VERTICALLY BAFFLED WITH TILE-ROOF SETTING AND B. & W. STOKER

has been removed for a distance of 4 ft. and T-tile substituted. This increases the heat absorption by the tubes and lowers the temperature of the furnace to a point where the brickwork can stand it. Apparently it has no detrimental effect on the smoke performance. In traveling along the heating surface, the flame is not "killed" as rapidly as when passing into a bank of tubes. Consequently, with the chain grate, a horizontal run of tubing can be bared to an extent necessary to maintain the furnace temperature at a point low enough to prevent excessive wear and tear on the brickwork. Fig. 7 shows a setting in which the first two rows of tubes have been bared for their full length without any detrimental effect on the smoke performance.

TILE-ROOF FURNACES

It is possible to obtain vertical gas passes in a boiler and at the same time get the long flame travel given by the horizontal-pass baffle, by using the tile-roof setting shown in Figs. 8 and 9. Fig. 8 shows the stoker under the back end of the boiler directly under the mud drum, and the tile roof extending to the first gas pass, after which the passes are similar to the standard vertically baffled water-tube boiler, with the flue gases taken off at the back end. This style of setting has given good satisfaction on high capacities when ample head room was obtainable.

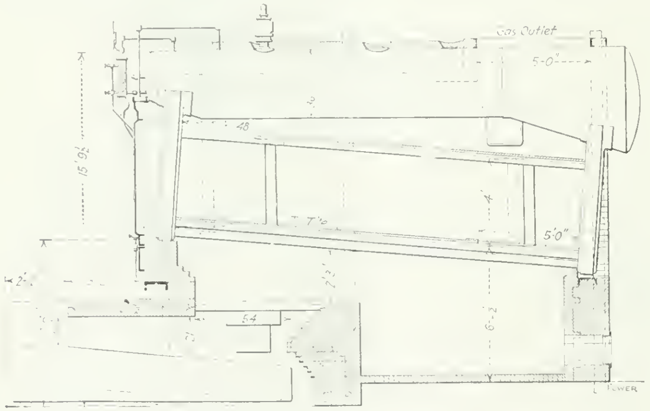

FIG. 9. GEARY 410-HP. BOILER AND GREEN INCLINED-CHAIN GRATE WITH BEMENT TILE-ROOF SETTING

Fig. 9 shows the stoker under the front end of the boiler as usual. The tile roof extends over the bridgewall as in the ordinary horizontally baffled boiler, and there are three vertical passes. The uptake is around the drums at the front of the boiler. These settings have all the advantages of the horizontally baffled boiler in the way of flame travel, etc., and at the same time have the advantages accredited to the vertically baffled boiler. The examples given are boilers with different tube pitch and stoker construction. These factors influence the head room required.

⁂

Power from Sewage Gas—A 16-hp. gas engine operates regularly on sewer gas in the sewage pumping station at Parramatta, Australia, says a correspondent in "The Power User." The gas is drawn directly from the septic tanks through 3000 ft. of pipe.

Why Ammonia Disappears from the Receiver

In the operation of a refrigeration plant, the liquid ammonia sometimes gradually disappears from the receiver, and many are puzzled to know where the liquid has gone.

The most frequent cause is the storing of the liquid in the ammonia condenser, if this apparatus is made of two or more pipe coils. This condition is brought about by the uneven distribution of the hot ammonia vapor throughout the condenser coils, and this action is in turn greatly influenced by the uniformity of the distribution of the cooling water through or over the coils, depending on what kind of condenser is used. If any one or more coils are furnished a greater quantity of water than others, or are so located as to receive a smaller amount of hot vapor, a lower pressure will be created in this section of the condenser, causing a flow of liquid into it from the liquid main.

It often happens that the flow of liquid into one or more sections is so strong that some of the ammonia vapor is drawn through the liquid outlet of one or more of the other sections or stands. This may be detected by the heating of these connections. When these pipes are closed off, the hot vapor, coming in larger quantities into the condenser in which the liquid is stored, will force the liquid back into the receiver, sometimes filling it.

Usually it is difficult to overcome this trouble, although it is due mostly to improper equalizing of pressure in the high-pressure end of the plant. One will often find it helpful to throttle the hot-gas valves in the condenser so that each is open about one-half turn. This may make the condenser pressure drop a pound or two, but better distribution of the gas often follows this action.

If the trouble is that the liquid has gone into the direct-expansion coils when these coils are below the suction line of the compressor, the reason for it remaining there is generally because these coils have frosted or become covered with ice, which prevents active evaporation of the liquid in the coils. If the liquid stores in the condenser coils, it usually returns from time to time to the receiver, but when it stores in the cooling coils it disappears gradually and remains in them until they are defrosted or the liquid is pumped out.

Many engineers favor the use of a low-pressure liquid receiver and a liquor pump for draining the liquid from the coils and forcing it back to the receiver. This may be put in at little cost, considering the convenience which it affords.

⁂

Removing Rust—Articles attacked by rust are said to be conveniently cleaned by dipping them in a well saturated solution of stannic chloride, 12 to 24 hours sufficing according to the thickness of the rust. An excess of acid in the solution must be avoided. After the objects have been removed from the bath they must be rinsed with water, then with ammonia, and quickly dried. They are said then to resemble dead silver.—"Iron Age."

Motors, Their Principles and Uses—V

By Gordon Fox

SYNOPSIS—Mechanical features of a motor installation, including methods of mounting and type of drive. Charts are included for determining pulley and belt data and selecting the proper gear ratios.

⁂

Motors may be mounted upon driven machines or upon the floor, side wall or ceiling, and may drive through couplings, gears, chains, belts or rope transmissions.

When mounted upon the floor, it is best to use a base or provide some means of keeping the motor above the dirt and moisture with sufficient space for sweeping. A base is better than rails, especially where the floor is uneven, due to the tendency of rails to settle away from a plane surface. Motor bases should be heavy enough to retain their shape under stress. A good method of insuring permanent alignment is to fasten the base down by lag screws, try out the motor and determine its final position, then pour lead around the lag screws, filling in the space in the bolt holes. Large motors may be neatly installed by providing a concrete foundation and anchor bolts, the motor being aligned with wedges and grouted in. Most motors are built with considerable end play. By magnetic attraction, the rotor and the stator are drawn opposite one another when in service, and if the shaft is not level, two opposing forces act upon it and an end pound results.

Motors may be readily arranged for side-wall suspension by shifting the bearing brackets through 90 deg. They are sometimes attached to the ceiling for driving through the floor to machines above. As the motor usually has a small pulley, it is necessary in such cases to bear in mind that the weight of the belt decreases the tractive power. It is not good practice to hang small direct-current motors directly from the ceiling, as they are inaccessible and do not receive proper attention; some sort of rack should be provided.

Direct-connected motors are best mounted as to be intrinsically a part of the driven machine. This is advisable for the sake of retaining alignment, but is not always necessary. Usually some form of bracket or platform is arranged, and if it is not possible to attach this to finished surfaces, it may be bolted to any part of the machine. The motor may be aligned and the bracket forced into position with wedges. A dam is then placed around the feet of the bracket and any spaces filled with lead.

Couplings

Flexible or solid couplings may be used for direct-connected motors. Flexible couplings should be used wherever there is vibration in the driven machine, where there is any possibility for relative movement of motor and machine, and where an end thrust occurs which might be imposed upon the motor; they may also be used as insulators. The most common kinds are, leather-link and leather-laced belt couplings and rubber-buffer couplings. The leather-link and rubber-buffer types are commonly used in small and medium sizes, while the leather-laced type finds favor for more severe work. There is some difficulty in securing uniform rubber which will retain its elastic properties. Leather couplings are not suitable in the presence of flying grit, oil or moisture. Solid couplings of the flange and compression types are the most commonly used.

Belt Drive

Belt drives are simple, flexible, inexpensive and elastic. affording protection to the motor in case of overloads and shocks. The drive occupies considerable space, however, is not so positive, and has a relatively high maintenance cost. Belt drives are undesirable for widely fluctuating loads, as heavy tension must be maintained for carrying the peaks and the losses under the light loads are proportionately high.

The power which can be transmitted by a belt varies with the speed, increasing nearly in direct proportion until a linear speed of about 4500 ft. per min. is reached. Beyond this, on account of increased centrifugal stresses, the effective transmitting power is reduced. Belt speeds between 2000 and 4000 linear ft. per min. are conservative values. Ordinarily, about 1000 ft. per min. is the minimum and 5000 ft. per min. the maximum. It is most economical to operate belts within the range of conservative speeds, due to lower first cost and maintenance and minimum power loss. Where very low speeds are used, wide belts are required. The center of the belt then overhangs the motor bearing some distance and trouble may ensue. Decrease of contact surface means higher belt stresses, due to greater tension required to prevent slipping. Wherever possible, the lower side of the belt should be made the driving side, so that the sag may be at the top. In determining pulley sizes, the allowable clearance and the belt speed are factors to consider, as well as the arc of contact on the smaller pulley.

The chart, Fig. 1, will be found useful for determining pulley and belt data. Consider that the speed of the driven machine and its pulley size are known. Find the intersection of the horizontal line representing pulley diameter and the diagonal representing speed. The vertical at this point represents belt travel. Follow this line to the diagonal of motor speed and the intersection will be on the horizontal giving the motor pulley diameter. Returning to belt travel, ordinarily follow this to the horizontal line representing 180 deg. arc of contact on the smaller pulley, then proceed along the diagonal to the horizontal representing the actual arc for the case in question, which can be readily approximated. Now follow the corrected vertical to the curve for type of smaller pulley used, and the horizontal line at this point will show the horsepower per inch width of belt desirable. From this the values of belt width and pulley face may be determined.

Single leather belts should, in general, be used for widths up to 6 in. and for use on pulleys less than 9 in. in diameter. Double leather belts should be used for most other installations except the very large, when triple belts may be used. Rubber belts are elastic, durable even under adverse conditions of temperature and moisture, have good tensile strength and are uniform in width and thickness; their tendency to stretch, however, is often a disadvantage. Laced belts should not be used for motor drives; endless belts are preferable. Belts should run

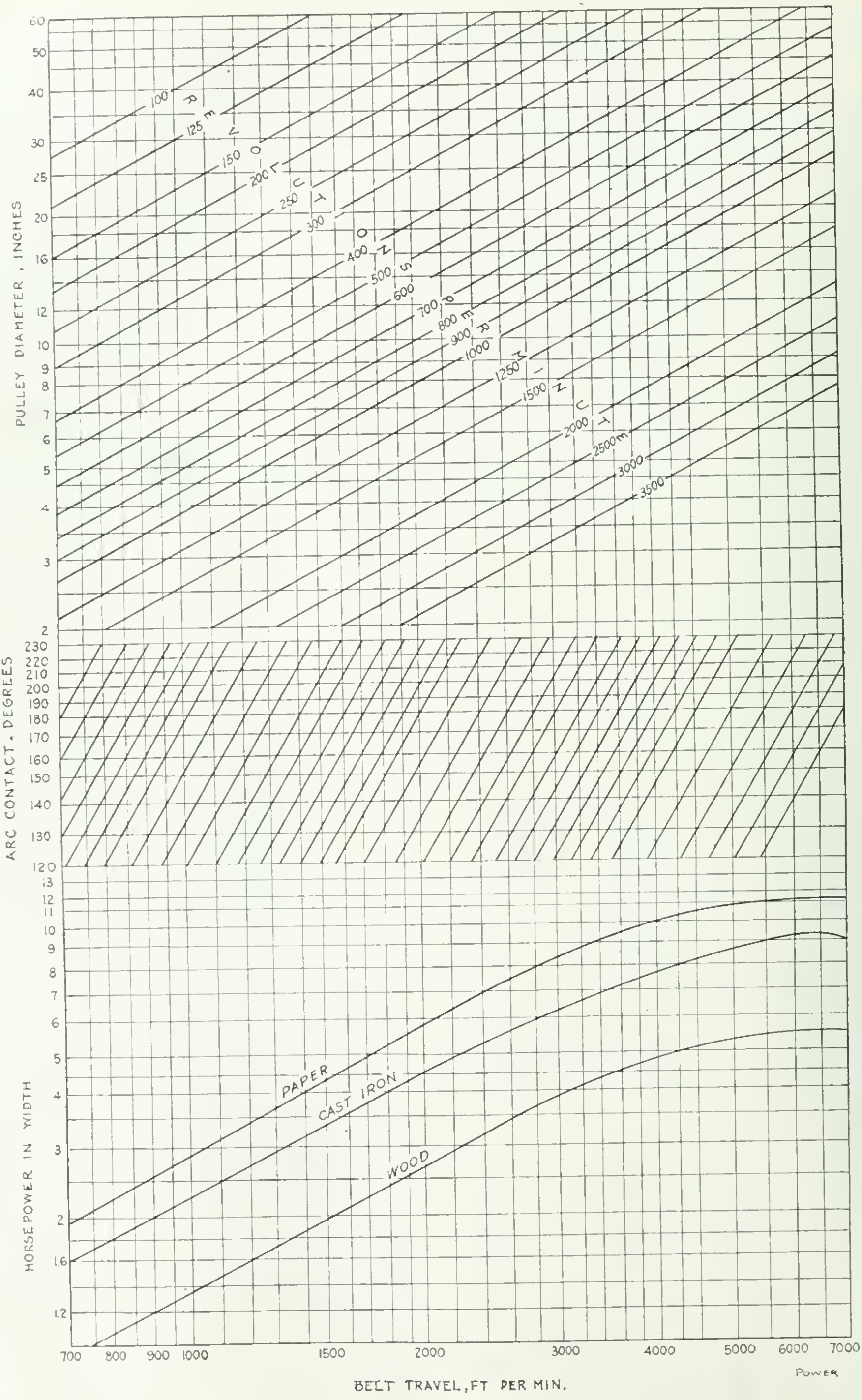

Fig. 1. Chart for Determining Belt and Pulley Data

with and not against the lap at the joint, and the joints should be smooth to prevent jarring. The wobbling of belts is sometimes due to pulleys having unlike crowns. Flapping is usually caused by slippage between some portion of the belt and pulleys, resulting from grease spots on the belt. A back-and-forth movement of the belt at the pulley is caused by the edges of the belt being of unequal arrangement. If the shafts are parallel, but the pulleys not directly opposite, the belt will run to one side of the larger pulley. If the pulleys are opposite, but the shafts not parallel, the belt will tend to run to one side of the smaller pulley.

The distance between centers of the motor and driven shafts depends upon the relative elevation of the smaller pulley and whether the belt pulls on top or bottom. The distance should be such as to allow a gentle sag. Five times the diameter of the larger pulley is usually a safe distance, provided the difference between the sizes of pulleys is not too great.

The maximum advisable ratios of reduction through a single set of pulleys are: 8 to 1 for motors about 5 hp., 6 to 1 for about 10 hp., 5 to 1 for 20 hp., and 4 to 1 for about 50 hp. If it is desired to ascertain the smallest pulley under which the motor bearings will give service, this may be done by figuring the total belt tension required, according to the formulas given below:

For iron pulleys,

$$\textit{tension} = \frac{3 \times \textit{horsepower} \times 33{,}000}{\textit{belt travel in ft. per min.}}$$

For wood pulleys,

$$\textit{tension} = \frac{2 \times \textit{horsepower} \times 33{,}000}{\textit{belt travel in ft. per min.}}$$

Knowing the tension at the center of the pulley, the distances between bearings and the overhang to the pulley center, the shaft may be considered as a simple lever, and the thrust on the bearing next to the pulley determined. The thrust per unit of projected bearing area may then be figured if the bearing dimensions are known. For motors under 50 hp., the pressure per square inch bearing area should not exceed 70 lb. For larger motors, pressures up to 100 lb. are allowable under favorable circumstances. Since belt tension must increase rapidly with a decrease of diameter, the limitations imposed by the bearings are usually the factors determining minimum diameter and maximum face.

Where there is insufficient space between the pulley centers to permit an open belt, or where the ratio of speed reduction desired is too great for open belting, or where a compact drive is desired, a belt-tightening device on the motor is warranted. As it affords good arcs of contact, low tensions may be used, and there is little or no loss in efficiency. Due to the elimination of the cost of a long belt, the drive is usually no more expensive than a simple belt drive. The ability of the belt tightener to decrease slippage and to lower maintenance expense as well as to increase reliability should recommend its use in many cases.

GEAR DRIVE

Gear drives are positive, compact and well adapted to low-speed work. They have fair efficiencies, ranging from 92 to 98%, but require careful alignment, are usually noisy and transmit all shocks to the motor. The allowable ratio of reduction is limited by the surface speed of the gear, the number of teeth and the pitch diameter. For small motors, a 10 to 1 ratio is allowable, and for moderate sizes, 8 to 1 is the maximum ratio permissible. The minimum number of epicycloidal teeth advisable for a pinion is 12, but with annular or internal gears, the pinion may have as low as eight teeth. When driven by a larger gear, the minimum number of epicycloidal teeth is 14. In calculating a given gear reduction, the gear should, if possible, have a prime number of teeth, so that shocks due to a repeated cycle of operations may be distributed; the use of an odd tooth prevents the same teeth from coming into mesh so often.

Gears are usually of cast iron or cast steel with cut teeth, while the pinions may be of steel, brass, fiber, rawhide or cloth, the latter types usually having end plates of brass. Steel pinions have excellent life and are not affected by temperature or moisture, but are noisy and cut quickly unless well lubricated. Steel gears are about twice as strong as cast iron and should be used when the face of the corresponding cast-iron gear would be 1.5 in. or more. The cost of cast-steel gears is nearly double that of cast-iron gears. The pinion is subject to the most rapid wear, due to its smaller diameter; therefore, it is important to have a pinion of good wearing qualities as well as of sufficient strength.

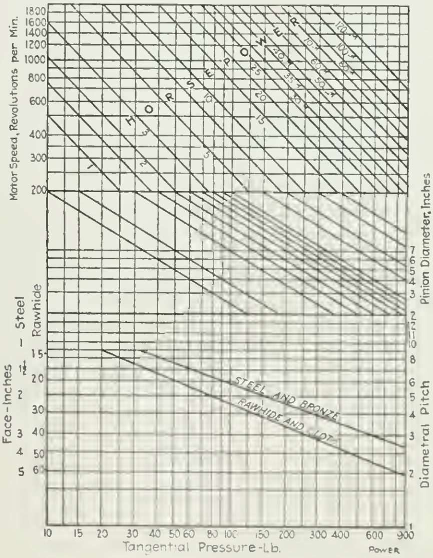

FIG. 2. CHART FOR COMPUTING GEAR DRIVES

Iron and steel gears ordinarily become noisy at about 800 ft. per min. linear surface speed, but may not become disagreeably noisy below 1200 ft. per min., or even higher.

Where it is desired to attain high surface speeds without noise, brass, fiber, rawhide or cloth pinions may be used. Brass pinions, although somewhat quieter, have shorter life than steel. They are particularly adapted to conditions of heat and moisture prohibiting the use of a nonmetal pinion, but where noise is objectionable. Fiber pinions are quiet, but are not very rugged and are subject to deterioration by moisture. Rawhide pinions are satisfactory unless subjected to extremes of heat or moisture or excessive load fluctuations or frequent starting, stopping or reversing. For equal strength, the face of rawhide pinions must be about 25 per cent. wider than corresponding steel pinions. The surface speed of a rawhide pinion is limited more by rapid wear than by noise. A speed of 2000 ft. per min. is a fair average limit, but 2500 to 3000 ft. per min. may be used under favorable circumstances of attendance and lubrication, in the absence of moisture and for intermittent service where the life of the pinion is not important. Cloth pinions are quiet, not easily affected by heat or moisture, are quite elastic and give good service even when subjected to strains and shocks. The allowable surface speeds correspond to the values for rawhide. Where quiet operation is desired, it should be noted that rigid and massive supports and close-fitting bearings both on the motor and driven machine are conducive to a noiseless drive. The pinion should always be placed as close as possible to the motor bearing.

Fig. 2 will be found useful in the selection of gears. Usually the horsepower, speeds and approximate distance between centers are given. With the gear ratios and center line distances given, an approximate pinion diameter may be selected. To use the chart, find the intersection of the horizontal line representing the motor speed with the horsepower diagonal. From this point follow the vertical of torque to the horizontal representing 1 ft. pinion radius, then follow along the diagonal to the horizontal representing the pinion diameter selected. The vertical at this point represents the tangential pressure at the pitch line. Following this vertical to the curves for steel and rawhide pinions, the approximate diametral pitch and gear face can be determined. The nearest commercial size that will give a good number of teeth should be selected.

Gears must be kept well oiled, and at high speeds some method must be used, the effectiveness of which will not be destroyed by centrifugal force. Rawhide gears should not be oiled, but should be lubricated with talcum and graphite or graphite and lard oil.

Worm gears are used for special cases where a large speed reduction is desired. They are positive, quiet and free from vibration. They have low efficiencies, ranging from 70 to 80 per cent., and require excellent machining and good lubrication. A carefully adjusted end thrust bearing must also be provided. The worm should mesh with the bottom of the gear and should run in oil. If the worm is placed above the gear, it will not receive good lubrication. The best rubbing-surface speed for worm gears is about 300 ft. per min., although speeds as high as 700 ft. per min. are sometimes permissible. Worm gears are not reversible: that is, the wheel will not drive the worm. They can sometimes be used in a braking capacity due to this feature.

Friction drives are useful where power is to be transmitted at high speed and low torque, for small amounts of power and where it is desired to change the speed or throw into and out of gear while in motion.

Chain Drive

The silent chain drive is excellent for many applications. It is quiet and efficient, and permits of compact layouts. Moreover, it can be used for wide reduction ratios, particularly where the motor cannot be placed close enough for gearing. It is a positive drive and does not afford protection to the motor through slippage. Its first cost is high and the expense of maintenance is usually greater than that of belts.

The center line distances for silent chain drives should be approximately equal to one-half the combined sprocket diameters plus half the diameter of the larger sprocket. In a vertical drive, the small wheel should not, if possible, be the upper one. Where feasible, it is best to have the pull on the bottom of the chain. To provide for elongation, particularly in vertical drives, where the chain tends to fall away from the lower sprocket, a sliding base should be used. The driven wheel should be flanged. Where the load is of a pulsating character, it is well to use a driven sprocket with a spring center to absorb fluctuations. Chains and wheels should be protected from dirt. When operating at speeds above 1300 ft. per min., they throw off their lubricant, and therefore should be inclosed and should run in oil.

Ordinary square-link chains are used for very slow-speed drives. They are cheap, positive, not affected by moisture and can be used in place of belts under heavy tension. Moreover, they do not require maintained lubrication. They are rated by numbers, as given in the following tabulation:

LINK CHAIN DATA

Chain No.	No. Links in 10 Ft.	Average Ultimate Strength in Lb.
25	133	700
35	74	1,200
45	74	1,600
55	74	2,200
66	60	2,600
75	46	4,000
85	30	7,600
95	30	8,700
110	25	12,700

The formula for determining the horsepower capacity is as follows:

$$horsepower = \frac{ultimate\ strength \times travel}{factor\ of\ safety \times 33{,}000}$$

The factors of safety are as follows:

Travel, ft. per min.	200	300	400	500	600	700
Factor of safety	6	8	10	12	16	20

If the load is irregular or subject to shock, use higher factors of safety. The working load depends upon the speed and the character of th work. At increased speeds, the chain is subject to greater shock and requires higher factors of safety.

Shafting is used in motor application work largely for group drives. As a guide to the selection of sizes, the following table is included:

HORSEPOWER CAPACITY OF COLD-ROLLED SHAFTING FOR COUNTERSHAFTS

Shaft Diameter in In.	Revolutions per Minute 100	150	200	250	300
1½	7	10	13	17	20
1⅝	9	13	17	21	26
1¾	11	16	21	27	32
2	16	24	32	40	48
2½	31	47	62	78	93

Bearings for countershafts should be spaced about 8 ft. apart. Where feasible, a countershaft should be provided with not more than three bearings. Pulleys should be placed close to the bearing, and if possible adjacent pulleys should pull in opposite directions.

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Smoke Abatement on the Pennsylvania—D. F. Crawford, superintendent of motive power of the Pennsylvania Lines west, left on July 15 on an inspection trip over the lines to see what can be done in regard to the abatement of the smoke nuisance. Mr. Crawford is an authority on this subject, and has been interested in the abatement of locomotive smoke for more than 25 years.

The Cost of Power

By H. M. Phillips

SYNOPSIS—Discussing the distribution of charges in keeping power-plant accounts, the author favors a fixed charge for repairs instead of charging off amounts actually expended. Determining the cost of a kilowatt or horsepower-hour before and after purchasing power.

⁂

The cost of a horsepower is often difficult to determine with justice to all interested. Where power is bought from a central station at a fixed price per kilowatt-hour, the engineer and the accountant know exactly where they stand; the only difficulties lie in estimating the amount of power that will be required for new machines and in dividing the total charge among the different departments or pieces of apparatus. None of these problems is likely to prove serious, and the latter can be eliminated by the use of a sufficient number of meters.

The accounting department can determine satisfactorily the cost of a horsepower in an isolated plant. The cost of fuel supplies and labor cannot be disputed; to these are added a series of overhead charges which may nearly double the amount and may bring the total up to $60 or $100 per horsepower-year, a figure that the operating engineer is apt to consider excessive and which is generally too high to be used on all occasions.

The most troublesome items of the overhead charge are office expense, repairs and depreciation. The power plant usually requires a small part of the time of the company's officials and clerical force and no accounting can be correct without including it.

Where repairs are charged according to the amount actually expended, that amount necessarily fluctuates from year to year, making an irregularity where a fixed charge is decidedly preferable. When the fixed charge is used it should be considerably above the amount ordinarily expended from year to year to provide for the serious break that is likely to come sooner or later.

In regard to depreciation, the engineer may complain that his accounts are loaded heavily with this item in spite of the facts that, owing to the alterations and repairs which have been charged to the plant, it is actually in better condition than when first installed; that during the years it has been in operation it has paid a fair proportion of the cost of a new outfit on these charges. Granted that this is true, it is certain that the old plant will be abandoned or replaced, and that it should be made o pay for itself before that time comes. The proper method is to have the charge diminished from year to year, so that a plant whose theoretical life is nearly run will not have to pay the same as one in the beginning of ts career; it should never be compelled to more than pay for itself on these charges.

Admitting that all of the foregoing items should be inluded in the cost of a horsepower and accepting the gures obtained by the auditing department, there are ill many difficulties in applying the figures to cases that requently arise to trouble the engineer. A central staon offers to supply electric power at a considerably lower ost per horsepower-year or kilowatt-hour than the mount charged against the steam plant. This is brought o the attention of the engineer with the suggestion that he reduce his operating expenses; then serious talk of purchased power follows, and perhaps the change is eventually made. In many cases it doubtless pays to abandon the old plant, and it may be assumed that the saving is carefully and accurately estimated before this is done, but during the preliminary stages the cost of a horsepower, as figured in making up factory costs, is the incorrect basis of comparison.

Omitting accounting of the cost of new apparatus and of making the change from one system to the other, what is to become of the interest on the original investment that constitutes a fairly large item in the cost of a horsepower? What is to become of the depreciation charge? The old equipment will be worth practically the same five years from now as at present, not much above the price of scrap iron. Will all of the labor charged against the cost of a horsepower be dispensed with and no additional labor be required? Not unless the present system of accounting is extremely good. Steam will still be required for heating in winter and probably for other purposes all of the year; there is probably other apparatus that receives attention from the engine-room staff, and the electric power will require some attention. Admitting that under the present system, steam for heating, labor and other expenses not actually expended in the generation of power that is to replace electric power, are properly charged on separate accounts, can those accounts be carried at the same cost under the new system? The cost of heating will undoubtedly be higher, and probably most of the other items also. For a comparison with the cost of electric power, the engineer can safely estimate the cost of a horsepower as that of the fuel, labor and supplies; and he should probably be able to deduct a fair amount from that figure or add it to the price quoted by the power company.

A new piece of apparatus requiring power is suggested for the factory or engine room. Will it be a profitable investment with the high power cost that will have to be charged against it? Assuming that it will not overload the plant, the actual increase in operating expense will be only that of the additional coal required, perhaps half of the value obtained from the total cost of a horsepower. In estimating the cost of power for this machine it will be hardly fair to charge it at a lower rate than the rest of the plant, but the only actual increase in power cost is for the coal consumed, and anything above this will be distributed as a profit over the rest of the plant in the form of a decrease in the total cost of a horsepower.

There is another side to this question. In nearly every going concern the amount of power used shows a steady increase from year to year, and the time is not distant when there must be an addition to the power plant. The new machine does its share toward forcing an extension of the plant, even though it is not necessary to make the addition for several years, and should be taxed accordingly.

The conscientious engineer is always endeavoring to increase the efficiency of his plant and frequently it is necessary to spend more or less money to effect the improvement. Will it pay? This is generally answered by the amount of coal that will be saved. If a horsepower will be saved, is not the engineer entitled to the same estimate that is made for the cost of a horsepower? If there is a saving of steam before it reaches the engine, should not all the overhead charges in connection with the generation of a pound of steam be included?

It is true that the only direct saving is in fuel, but he is also easing the load on the plant which may be the means of preventing a breakdown at some future date; he is also postponing the time when the plant must be enlarged. The fact that the amount of power involved in a single instance is small should in no way alter its treatment in this respect. True, 1 hp. more or less will never cause a breakdown or mean enlarging a plant, but "it is the last straw that breaks the camel's back." It must be remembered that this saving may be one of a hundred or more similar ones that arise in a few years.

Still another case that is treated unfairly by using the accredited value of a horsepower-hour is the installation of a machine using a large amount of power for short periods only, and with long intervals of rest. Such a machine may call for a large portion of the total plant capacity while in operation, but consume a comparatively few horsepower-hours during the month or year.

Assuming that fuel constitutes one-half the value of a horsepower, it would not be unjust to charge the machine in question with one-half the amount that it would require for continuous operation and to add to that the amount of fuel it actually requires, or, what is the same thing, add its horsepower-hours charged at half the usual rate. This method would be too severe, especially if the machine carried its load for short periods only, but a higher charge should be made than for a machine that is in continuous operation.

Power companies fully realize the justice of such a system of charging and establish their rates accordingly at the risk of dissatisfied customers and interference by legislation or public-service commissions. Their customers are provided with a maximum demand meter, which records the maximum number of kilowatt-hours used during a short period (fifteen minutes) during the month. Two customers may use the same number of kilowatt-hours recorded by the ordinary meter during the month, but one will show twice the maximum demand of the other; the one with the higher demand will be charged at a higher rate than the other. Such a system is not entirely fair for all cases, for the customer showing the high demand may have been using that amount for several hours each day during the time of maximum load on the station and running comparatively light for the rest of the time, which would be hard on the station and deserve a high charge.

Then, again, he may have been running a fairly constant load for one-half of the month and have shut down the other half, which would not be so bad; or he may have been running for the entire month at practically the same rate as the customer with half the maximum demand reading, but have used power at the higher rate on a single occasion for 15 minutes only and during a rather light load on the station, in which case it would be hardly fair to increase his rate. It is practically impossible to obtain exact data as to how the customer uses power and to charge accordingly, but the system referred to is likely to be fair in the majority of cases and is an incentive to the customer to avoid throwing on excessive loads for short periods. The fixed charge per kilowatt-hour, which makes the customers who use power at a fairly uniform rate stand a portion of the cost of supplying those who carry their load for short intervals only, is certainly unfair to the former. It is equally unfair to charge machines that operate continuously with a part of the cost of furnishing power for the one that operates infrequently.

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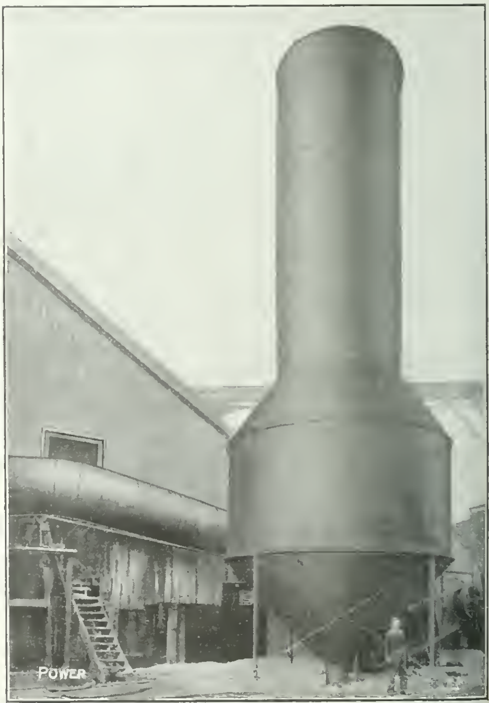
Mechanical Draft Installation Collects Cinders and Sparks

The Bloedel-Donovan Co., Bellingham, Wash., recently installed a successful induced-draft apparatus, the magnitude of which can be appreciated by comparing it to the man in the foreground.

This apparatus is designed to collect all sparks and cinders, and thus eliminate the fire risk. The cinders are caught in the collector and diverted into a flume of water, which empties into Puget Sound.



Collector and Mechanical Draft Fan

The apparatus also makes it possible to keep the lumber in the yards clean, and is used in connection with boilers burning shavings and sawmill refuse. At the time the photograph was taken, the boilers were delivering 2300 hp., which is greatly in excess of their normal rating. This increase in boiler capacity is due to the additional draft obtainable with the induced system.

Another advantage is that steam is kept constant at any desired pressure. When the pressure tends to decrease, the fan speeds up automatically and does not allow the pressure to drop. This enables the plant to respond to sudden demands for more steam.

The installation was made by the B. F. Sturtevant Co.

Tests of Substitutes for Gasoline[*]

By J. A. Moyer[†]

SYNOPSIS—Comparative tests of kerosene, alcohol, motor spirit and mixtures of kerosene and gasoline as substitutes for gasoline in engines; also the effect of water injection as determined for each of these cases and air injection for gasoline alone.

⁂

Generally speaking, gasoline is the only fuel used for automobiles in this country, while enormous quantities are required for farm tractors, as well as for stationary and marine engines of all types. The investigations herein described were conducted during the past year by the Engineering Experiment Station of the Pennsylvania State College to determine the applicability of kerosene, alcohol, motor spirit and mixtures of gasoline and kerosene as substitutes for gasoline in engines. Most important results, as regards the effect of the injection of water and air on the capacity and economy of the engines, were also obtained, and tests and experiments to determine the underlying reasons for the peculiar action of water when sprayed into the combustible mixture before it enters the cylinder, are being continued.

The consumption of gasoline for power purposes has increased enormously during the past few years, as the following table shows:

TABLE 1. CONSUMPTION OF GASOLINE IN THE UNITED STATES

Year	Bbls.
1910	5,375,000
1912	12,000,000 (124% increase over 1910)
1911 (estimated)	25,000,000 (366% increase over 1910)

A few years ago, this country supplied the world with gasoline, while in 1913 our exports were only one-fifth of the total reqnired for the demand in foreign countries. If the home consumption continues in anything like the same rate, the United States will soon have no gasoline to export.

The enormous increase in the demand for gasoline is due to the great increase in the number of automobiles and auto trucks. In 1902 there were only 15,000; in 1912, more than 900,000 and in 1914 it is stated that one manufacturer alone will produce 300,000 automobiles. In the ten years from 1902 to 1912, for which period we have the most correct data, the number of vehicles using gasoline for motive power has increased sixty-fold, while the production of the grades of *crude petroleum* most suitable for making gasoline increased only 100 per cent.

Methods of Increasing the Production of Gasoline

Using Heavier Distillates—There is not now and never has been a definite standard of gravity test for the petroleum products. Gasoline as sold in commerce may have a specific gravity as high as 0.72, equivalent to 64 deg. Baumé. In the early history of the oil industry, the lighter distillates of petroleum were considered dangerous and practically useless. Gasoline was then very cheap and the refiners were glad to find a market for it at any price. Under these circumstances naturally the production of gasoline would be limited as much as possible and only the lightest distillates, such as would vaporize and form an inflammable mixture at room temperatures, were sold under this classification. With the rapid development of gasoline engines, however, the conditions have so much changed that the refiner now seeks to make the production of gasoline from crude oil as large as possible and includes under this name a large part of the distillates which do not vaporize readily at ordinary temperatures.

Compressing Natural Gas—Another important process for making gasoline is that of compressing natural gas. In the natural-gas regions the gas is known as "wet" and "dry," depending on its condition as regards saturation with oil. What is known as "wet" gas is saturated with gasoline vapors or light hydrocarbons.[**] When the "wet" gas is subjected to high pressure and low temperature, the gasoline vapors are condensed and are readily separated from the gas. This product from the compression of natural gas is extremely light and of varying volatility and must usually be mixed with a heavier petroleum distillate to make a product approaching the gravity of commercial gasoline.

Cracking—Equally important is the method of converting heavy petroleum oils into gasoline by the method of "cracking" or dissociation, which consists essentially in breaking up, by the application of heat under favorable circumstances, the heavy petroleum products into lighter distillates of entirely different atomic proportions.

This method was first demonstrated by Thorpe and Young, in 1871, but was not developed commercially until about 1913, when the exceptionally high prices for gasoline spurred investigators to an unusual degree to find new processes to meet the demand. These early investigators showed that by applying heat to solid paraffin, it could be converted into the vapors of hydrocarbons (paraffin and olefines), which are liquid at ordinary temperatures. By the simultaneous application of both heat and pressure to solid paraffin in a closed retort, these liquid hydrocarbons can be separated and removed from the heavier constituents. In its commercial application, "cracking" consists in bringing a suitable heavy petroleum product together with a relatively small quantity of water into contact with a large surface of iron or steel in highly heated retorts, and as a result a considerable percentage of the heavy distillate, depending, of course, on its physical properties, is converted into gasoline.

Substitutes for Gasoline

Kerosene—By far the most important substitute for gasoline having any considerable advantage from the viewpoint of the engineer is the ordinary kerosene of commerce. During the past few years the production of kerosene in this country has been much larger than the demand, and, compared with gasoline, the price is, therefore, nnusually low. The great commercial advantages which would result if kerosene could be satisfactorily substituted for gasoline can be best appreciated when it is considered that the crude oils now used for supplying gasoline will supply kerosene up to 50 per cent. of their volume, while the gasoline production from these oils by distillation alone is seldom more than 8 to 10 per cent.

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[*] Complete data and results will be published later in Bulletin No. 7, of the Engineering Experiment Station, by J. A. Moyer and E. N. Bates.

[†] Professor of Mechanical Engineering in the Pennsylvania State College.

[**] Natural gas contains some methane (CH_4), pentane (C_5H_{12}), hexane (C_6H_{14}), etc., all of which are liquid at ordinary temperatures after they have been removed from the gas.

Kerosene has a slightly higher heat value than gasoline per unit of volume, as shown by Table 2.

TABLE 2. CALORIFIC VALUES FOR KEROSENE, GASOLINE AND ALCOHOL

Fuel	Sp.Gr.	B.t.u. per Lb.	B t.u. per Gal.
Gasoline	0.72	20,462	122,776
Kerosene	0.80	19,890	132,700
Alcohol	0.836	8,875	61,800

Until our supplies of gasoline became limited, the principal demand for kerosene was for illumination, which demand is now diminishing. Fortunately, however, there has been a steadily increasing demand for kerosene for use in cooking and heating stoves, and also in the constantly increasing requirements for farm engines of both the stationary and tractor types.

In thickly populated districts the use of kerosene in engines is objectionable, on account of the difficulty in securing a clean and odorless exhaust by the use of the ordinary types of carburetors. Many motor vehicles are being operated without this difficulty with the exhaust by using a mixture of gasoline and half kerosene. Whenever kerosene is to be used alone for the operation of an engine a carburetor suited to this particular type of fuel must be used for successful operation.

When kerosene is used in automobiles, except under conditions of unusual carefulness, it is difficult to prevent the chassis and even the interior of the body from becoming unpleasantly odorous.

As regards storage, kerosene is much more satisfactory. Gasoline vaporizes readily at ordinary temperatures and there is considerable loss by vaporization from storage tanks; also this vapor increases the fire hazard. Kerosene, on the other hand, does not vaporize readily at ordinary temperatures, therefore is less dangerous and can be stored without much loss from vaporization.

Motor Spirit—This petroleum distillate is a low grade of gasoline, which is marketed at a lower price than gasoline. It has more color than gasoline and kerosene, having a decided yellowish tinge. Its specific gravity is 0.73, or about 63 degrees Beaumé.

Acohol—The denaturated alcohol used in these tests was of the kind obtainable commercially from large producers. The specific gravity was 0.836, equivalent to 37 degrees Beaumé and corresponding to 80 per cent. alcohol by volume, or 76.1 per cent. by weight. The lower heat value was 8875 B.t.u. per pound, and the price 45c. per gallon in barrel lots.

Alcohol can be used successfully in any engine adapted to the use of light petroleum products. Engines designed primarily for using gasoline will run satisfactorily with normal compression when operated with alcohol fed through almost any of the good commercial types of carburetors. However, it is usually just as difficult to start an engine with alcohol as with kerosene; hence it is desirable to start with gasoline to heat up the engine and then open the connection to the alcohol tank.

As long as the price per gallon of alcohol is not considerably lower than gasoline, it cannot come into general use for power purposes. The tests, which will be described later, show that the efficiency of the engine is about the same for alcohol and gasoline,†† and Table 2 shows that the heat resulting from combustion is (in B.t.u. per gallon) about 61,800 for alcohol and 122,700 for gasoline. There is, therefore, about twice as much power available from a gallon of gasoline as from the same measure of alcohol.

Comparison of Fuels with and without Water Injection

The tests recorded here were made on a four-stroke-cycle stationary type of water-cooled engine, designed particularly for operation with gasoline. The cylinder bore was 6¾ in. by 10-in. stroke, and governing was by the "hit-and-miss" method. The primary object was to determine the maximum power and fuel consumption for each of the fuels used; first, without injecting water into the fuel-intake pipe and, later, with water injection. It is well known that the injection of water is effective in preventing so-called preignition, especially with fuels like kerosene, which is prone to produce excessive "pounding" in the cylinder when running under heavy load. It has been contended that the water injected with the fuel would, since it becomes superheated steam, have a beneficial effect, both as regards the maximum power obtained and the fuel consumption. The tests showed that the maximum horsepower of the engine is considerably increased, especially when kerosene is used for fuel; but in all cases with a sacrifice of economy; that is, the fuel consumption per horsepower-hour is considerably greater with water injection.

These tests were made with a carburetor, in which the fuel was discharged under pressure in a fine vapor from a special spraying device. The carburetor was effectively heated with the exhaust gases, and after the engine was once heated uniformly, its operation was very little affected by varying the amount of heating of the mixture within the carburetor. The amount of water injected was regulated by hand with a needle valve; in every case just enough being injected to prevent unusual pounding. Ignition timing in this series was practically the same for all tests.

Kerosene—The following data are the results of tests made under these conditions when using kerosene for fuel.

TABLE 3. KEROSENE (SP. GR. = 0.80) WITH WATER INJECTION

No. of Test	Brake Hp.	Fuel Used, Lb. per B.Hp.-Hr.	Water Injected, Per Cent.***	Fuel Cost per B.Hp.-Hr., Cents
1	6.03	1.33	71.5	1.80
2	8.05	1.20	75.8	1.62
3	8.11	1.19	70.4	1.61
4	8.97	1.12	33.3	1.51
5	10.99	1.09	48.9	1.47
6	11.09	....	122.0	....

***Percentage by weight of fuel used. The price of the kerosene was 9 cents per gallon in both cases.

TABLE 4. KEROSENE (SP. GR. = 0.80) WITHOUT WATER INJECTION

No. of Test	Brake Hp.	Fuel Used, Lb. per B.Hp.-Hr.	Water Injected, Per Cent	Fuel Cost per B.Hp.-Hr., Cents
7	3.67	1.328	0	1.79
8	6.05	1.250	0	1.69
9	8.36	1.053	0	1.43

Fig. 1 shows graphically the results given in Tables 3 and 4. It will be observed that the maximum power of the engine was increased from 8.36 horsepower, which was the safe limit without water injection, to 11.09 horsepower with water injection. For all powers, however, the amount of fuel used was greater when there was water injection and consequently the cost per unit of power was also greater. Obviously, it is most desirable, therefore, to cut off the supply of injection water entirely at light loads, and carburetors designed for injecting water automatically into the combustible mixture should be arranged to cut off the supply of water automatically at light loads. Test 6 is added to Table 3, merely to show that the engine operated satisfactorily even when the weight of water injected was 22 per cent. greater than the kerosene.

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††This holds true when the same degree of compression is used for both gasoline and alcohol. However, with alcohol it is possible to employ much higher compression, in which case a higher thermal efficiency is obtained; see Bulletin 43, Bureau of Mines.—Editor.

Mixture of Kerosene and Gasoline

Another set of tests was made using a mixture of half gasoline and half kerosene by volume. The price of the kerosene was 9c. and the gasoline 18c. per gallon.

TABLE 5. KEROSENE AND GASOLINE (HALF AND HALF BY VOLUME) WITH WATER INJECTION

Sp. Gr. of Kerosene, 0 80; Sp. Gr. of Gasoline, 0 72

No of Test	Brake Hp.	Fuel Used, Lb. per B.Hp.-Hr.	Water Injected, Per Cent.	Fuel Cost per B Hp.-Hr., Cents
10	4 07	1 250	9 0	2.67
11	7 99	0.974	22 9	2.07
12	8 02	1.050	67.5	2.24
13	8 04	0.992	40 2	2.12
14	10.70	0.845	99 5	1.80
15	10.88	0.820	82.3	1.75
16	10.90	0.923	76 3	1.97

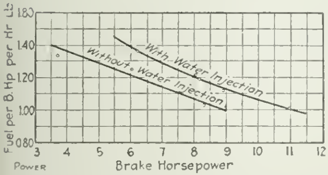

FIG. 1. KEROSENE WITH AND WITHOUT WATER INJECTION

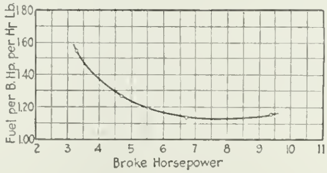

FIG. 2. FUEL CONSUMPTION VS. BRAKE HORSEPOWER WITH ALCOHOL

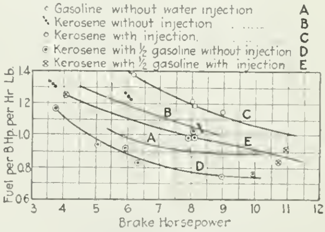

FIG. 3. ECONOMY CURVES FOR DIFFERENT FUELS TESTED

TABLE 6. KEROSENE AND GASOLINE (HALF AND HALF BY VOLUME) WITHOUT WATER INJECTION

Sp. Gr. of Kerosene, 0 80; Sp Gr of Gasoline, 0 72.

No. of Test	Brake Hp.	Fuel Used, Lb. per B Hp.-Hr	Water Injected, Per Cent.	Fuel Cost per B.Hp.-Hr., Cents
17	2 64	2 50	0	5 33
18	3 72	1 17	0	2 50
19	5 12	0 94	0	2 02
20	5 98	0.92	0	1 97
21	8 23	0 82	0	1 67
22	8.92	0 74	0	1 58
23	9 92	0.76	0	1 62

Motor Spirit

A few tests were made, using the same engine and the experimental carburetor, with motor spirit. The results, as shown in Table 7, indicate also that with this fuel water injection is detrimental to economy.

TABLE 7 MOTOR SPIRIT, WITH AND WITHOUT WATER INJECTION

Sp. Gr. 0 73

No. of Test	Brake Hp.	Fuel Used, Lb per B.Hp -Hr	Water Injected, Per Cent.	Fuel Cost per B Hp -Hr., Cents
21	7 93	0 80	60 1	2 12
25	7 93	0 84	59 9	2 22
26	7 93	0 78	0	2.05

Price of motor spirit, 16 cents per gallon

Gasoline

For the purpose of comparison, tests similar to those given in the preceding table, were made with gasoline. No tests, however, were made with this fuel when water was injected into the cylinder, as the sort of "pounding" in the cylinder observable with the other fuels did not occur.

TABLE 8. GASOLINE, WITHOUT WATER INJECTION

Sp. Gr. 0 72

No of Test	Brake Hp.	Fuel Used, Lb. per B.Hp.-Hr.	Water Injected, Per Cent.	Fuel Cost per B.Hp.-Hr., Cents
27	3 71	2 17	0	6.52
28	5 88	0 99	0	2 97
29	7 93	0 86	0	2.58
30	7 95	0 86	0	2.58
31	9 91	0.85	0	2.55

Price of gasoline, 18 cents per gallon.

Fig. 3 shows curves of fuel consumption plotted against brake horsepower for kerosene, the mixture of half kerosene and half gasoline and also gasoline alone, and shows clearly the effect of water injection in all cases.

Alcohol

Similar tests were made with gasoline, kerosene and alcohol in a high-speed experimental automobile engine with water-jacketed cylinders. The carburetor used was a Russian make and was designed especially for use with alcohol and kerosene. Brief data of these tests are given in Table 9.

TABLE 9. ALCOHOL WITH NORMAL COMPRESSION, WITHOUT WATER INJECTION

Sp. Gr 0 836

No. of Test	Duration of Test, Min.	R p.m.	Brake Hp.	Fuel Used, Lb per B.Hp -Hr.	Fuel Cost per B Hp.-Hr, Cents
32	60	533	3 22	1 56	10 70
33	60	585	4 63	1 29	8 92
34	30	725	6 66	1.12	7 80
35	30	1029	9 45	1 16	8 02

Price of denatured alcohol, 45 cents per gallon.

Two tests were also made with thirty-three and fifty per cent. water injection with the following results:

TABLE 10 ALCOHOL, WITH NORMAL COMPRESSION AND WATER INJECTION

Sp.Gr 0.836

No of Test	Duration of Test, Min	R.p.m.	Brake Hp	Fuel Used, Lb per B.Hp -Hr	Water Injection, Per Cent.	Fuel Cost per B Hp.-Hr, Cents
36	30	766	5 65	1 43	33	9 87
37	30	641	4 73	1 66	50	11 45

Fig. 2 shows the fuel used without water injection per brake horsepower-hour at 5.65 horsepower to be 1.19 pounds, and according to Test No. 36, Table 10, the consumption for the same power with 33 per cent. water injection is 1.43 pounds. Similarly at 4.73 horsepower the fuel consumption from the curve is 1.29 pounds and from Test No. 37, 1.66 pounds. All the tests, therefore, indicate that there is a loss with water injection.

Tests with Air Injection

A four-cylinder, air-cooled automobile engine was tested with a commercial type of carburetor. The so-called air-injection device is illustrated in wide-open position in Fig. 4, and consists of a central cylindrical valve with scalloped ports, controlled by the lever *A*. The valve is held down on its seat by the spiral spring. Small movements of the valve from the closed position make relatively much smaller areas for the admission of the air than the same amount of movement when nearly wide open. The thread shown on the apparatus is to be screwed into the inlet manifold of the engine. The opening of the valve was varied in the tests recorded in Table 2, in which the engine was operated with gasoline.

TABLE 11. AUTOMOBILE ENGINE OPERATED ON GASOLINE, WITH AIR INJECTION

No. of Test	Brake Hp.	Fuel Used, Lb. per B.Hp.-Hr.	Opening of Air Injection Valve, In.
45	10.76	0.976	0
46	12.14	1.007	0
47	11.70	0.864	0.11
48	11.01	0.804	0.14
49	11.40	0.838	0.20

It will be observed from these data that the economy of the engine is considerably improved when air is "injected" into the manifold. Extreme care was taken to get the best possible adjustment of the carburetor before the air "injection" device was used. An intermediate position of the air valve gave the best results; that is, an opening of 0.14 in. gave lower fuel consumption than openings of 0.20 and 0.11 in.

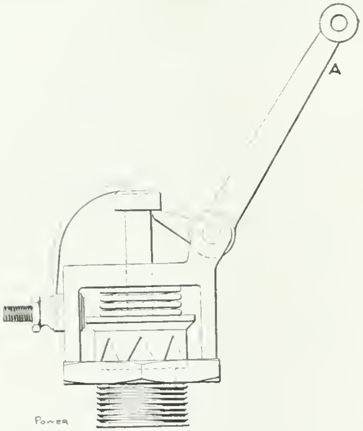

Fig. 4. Showing Valve and Portholes with Air Valve Open

The same device has been tested on various types of carburetors on both air-cooled and water-cooled automobile and aeroplane engines, and in every case improvement in economy has been shown. For average road operation on automobiles where carburetors are set for relatively rich mixtures for a quick "get-away," such a device for making lean mixtures is serviceable and economical.

Cause of Preignition in Kerosene Engines

What has usually been called "preignition" in engines operating with kerosene and distinguished by a sharp pounding at the connecting-rod, is probably not preignition at all, as shown by many indicator diagrams taken on these engines when the pounding was severe. The explosion, which appears to be violent, does not occur until after the piston is started on the return stroke. This may be due to a "cracking" of the heavier portion of the kerosene, which, due to the lack of high temperature necessary to vaporize it, has been carried into the cylinder in minute drops and under the high temperature and high pressure of compression, breaks up into an explosive gas and a very heavy oil or even carbon.

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Vacuum Heating without Thermostats

By E. F. Henry

"A vacuum system is an ordinary gravity return system with a college education," it was stated a few days ago. It causes speculation as to whether the college education is any more necessary to the gravity system than it is to some young men.

The large virtue of the vacuum system is that it enables more heat to be abstracted from the steam before it is thrown away than in the older systems. To do this it is necessary to make a condenser of the heating system so that only hot water will return to the vacuum pump. Provision is always made for injecting water into the return pipe, so that the pump will not attempt to pump steam, and so that the temperature of the return can be kept enough below the boiling point not to flash into steam in the pump cylinder and prevent the pump from working. All this is supposedly taken care of by the thermostatic valves on the return end of each radiator and coil.

Like all other thermostatic apparatus, some work better than others, but it has been found by operating engineers that if the thermostat will not work it can be removed, like a man's vermiform appendix—without great inconvenience to the patient. All that is necessary is a globe valve with the handle removed, so that each one can be adjusted to the requirements of its coil. Theory or no theory, it is found that the opening necessary to take care of a given coil is practically independent of the weather. If more heat is needed, increase the vacuum, and the returns will respond without changing the setting of the valves.

All the functions of the system are preserved, it acts as a condenser and nothing but hot water comes back, provided no change is made in setting the valves. Of course, a half-inch valve wide open will let steam out of a radiator, unless it is a pretty big one, but that is no more likely to happen than for a thermostat to go wrong, possibly not quite as much so.

Stripped of the thermostat, the vacuum system becomes as simple a proposition to install as a gravity return that discharges into a tank from which boiler-feed water is taken, plus the advantage that the vacuum will take care of a great many little traps in the piping that come about, not always through faulty construction, but because of pipes getting bent or pipe hooks coming out, and so on.

The difference in cost of water consumed, the cost of heating feed water and the greater range of temperature in the radiators, would make changing over an old plant to a vacuum system almost always a paying proposition, particularly if the man in charge of the power plant has nerve and confidence enough to tackle the job without a high-priced engineer to lay it out.

Editorials

"Pass It On"--To Whom?

In an editorial in the Mar. 24 issue, we called attention to the many trade publications, magazines, etc., that are skimmed over if looked at at all, tossed aside to be read "some day," relegated to the waste pile in the back room, or sent at once to the furnace room without seeing if they may not contain articles or advertisements of present financial value. If such shall be their fate, they are an expense and a nuisance.

But the day of large wastes is nearly at an end. What may be waste product to one man is raw, necessary and valuable material to the next man. The question therefore is, "Who is the next man in your organization who should look over your waste product and get good value therefrom?"

It is being answered differently in large engineering works. In these works a clerk takes charge of the periodicals, magazines, professional papers, and trade catalogs pertaining to their industry, and sees that they are temptingly displayed in the reading room of the office building, to be read during the noon hour or taken home at night to be read with more care.

This is admirable for the office force, the salesmen, clerks, and others who may have the time and want to accept the opportunity. But what about the men in the works, the superintendents, foremen, chemists, engineers and other specialists? Might not one of those papers give him just the idea, to get that for which the company has been spending perhaps thousands of dollars in experimentation? Would not the knowledge that a new machine has been put on the market or that a new process has been devised, the use of which may halve the cost of production of some part, cause further inquiry to be made and the possible saving to be effected? Might not these new savings, even if made only occasionally, pay well for the cost of some system that will keep the organization well informed on subjects pertaining to the company's output and system of manufacture?

System has now touched many lines of industry, but only occasionally do we find that it regulates the disposal of incoming printed matter. Why not, as other goods are treated, send it to the receiving room, route it to its proper department, even list it in the inventory, and hold someone responsible for it until it has been used in the routine work of the shop, factory, or plant?

To further conserve time, let each piece of printed matter such as catalogs, technical and professional papers, and the like, be entitled in ink with its general character, if its title is not fully explanatory. Then rubber-stamp in the margin of the title cover the names or initials of each of those men who may be held responsible for having read certain of the articles. Some technically trained person should act as routing clerk, read the titles of the articles, skim their contents, decide as to the real subject matter of each article and of its value to the organization, mark the page number of those articles that he thinks certain men should read opposite their name or initials on the margin of the cover, and send it to them in sequence. Those assigned an article should promptly read it with such care, make such notes, and take such further action, as they may think wise for the good of the company, sign their initials and the date on the line with their name on the assignment stamping, and forward it automatically by interworks mail to the next one on the assignment, and so back to the routing clerk for filing.

A still further refinement of this system is that of having weekly meetings at which certain ones will be expected to tell what they have read, since they last reported, which they consider of greatest value to the organization. This meeting may be held during or just after the noon hour, or in the evening if such seems desirable and necessary.

For the advancement of your men and your business, after you have read a trade paper or a technical article in a professional journal, *pass it on* to those of your employees who are most interested, and do not waste these "goods receivable."

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Companions--Prosperity and Power

On October the fourth the European catastrophe had endured two months. Considering the gigantic proportions in men and area immediately affected, and realizing that those engaged are world powers in business as well as armament, there is little wonder that industry the world over should suffer; that banking restrictions should exist, and that securities be more or less demoralized.

For Europe the outlook is dark. The business which the belligerents did with one another has ceased and just how soon after the conflict it will be resumed and how completely, one can only conjecture at this time.

Within recent years, Germany has become a nation of importance in the manufacture of engineering materials. These amounted to approximately twenty-billion dollars annually. Of the total export trade in electrical equipment, nearly thirty-five per cent. went to those with whom she is now at war, the rest was distributed through the United States, South America, Africa and the Orient. Coal costs considerable in South America, and to furnish power to her growing industries her water-power resources are being developed, calling for an ever-increasing importation of electrical and power equipment, particularly by Brazil, Argentine and Chile. Heretofore, Germany has exported the largest share of this class of equipment to Argentina and was a strong competitor throughout South America, whose total imports in electrical machinery and supplies amount to more than twenty millions. These countries have always been heavy consumers of European coal, and this is another good field for American industry.

Steel is an excellent barometer by which to judge economic conditions. We read that large orders from abroad for steel and machinery have already been placed and more are awaiting adjustments. Also, commercial reports announce large orders for various goods placed here and there by foreign business houses, orders which do not excite wonder by their magnitude but greatly encourage because they are for goods for people who heretofore have bought elsewhere.

It remains then to shoulder the responsibility thrust on us at a time when the belligerents are too grossly engaged in battle to properly attend to their business possibilities, and to make the quality of our goods, the facility of our service and the character of our exchange such that our new buyers will stay with us to an extent great enough to pay for going after their business.

American industry has received an unprecedented impetus. Availability of power and equipment for its application always have, and must in this instance, precede the growth of industry. Resumed activity of industries has a like effect on power plants and allied industries for prosperity and power are inseparable and interdependent companions.

Percentage of Vacuum

What is meant when a condenser manufacturer guarantees to produce a vacuum within a given percentage "of the possible"?

The natural inference would be that the vacuum should be the given percentage of that indicated by the barometer. If the barometer were, for example, 29 inches and the vacuum was to be 95 per cent. of the possible, one would suppose that the condenser must produce a vacuum of $0.95 \times 29 = 27.55$ inches. But in no condenser can the absolute pressure be less than that due to the temperature of the water vapor present. If air is present, the absolute pressure will be the sum of the pressures of the air and the water vapor.

It is the function of the condenser to get the condensate as cool as practicable and to remove the air as quickly as possible. The first requires a large condenser with plenty of injection or circulating water, the second, large air-pump capacity; but no matter how much condenser and air pump the manufacturer may furnish, he can never reduce the absolute pressure to less than that due to the temperature of the condensate. Furthermore, no matter how much water is used, the temperature of the condensate can never be quite reduced to the temperature of the condensing water. This sets a limit to the possibilities and makes possible another interpretation of a guarantee in terms of "per cent. of the possible."

To make the observation concrete, suppose a barometer of 29.8 inches; condensing water of 70 degrees; vacuum obtained 28 inches.

The vacuum obtained is $28 \div 29.8 = 93.96$ per cent. of the barometer.

But even with a high-vacuum water-jet pump it is impossible to get the temperature in the condenser less than 70 degrees, and at this temperature water vapor having a pressure of 0.739 inch will be generated. The best vacuum theoretically possible is therefore $29.8 - 0.739 = 29.061$ inches, and the 28 inches produced by the condenser is 96.35 per cent. of this possible.

If, however, the best possible vacuum is to be computed thus from the temperature of the condensate, the maker might furnish an inadequate condenser which would run warm and produce a poor vacuum; but this poor vacuum would still be a high percentage of that attainable at the high temperature. For instance, a condenser cools its condensate to 110 degrees and produces a vacuum of 26 inches with a 30-inch barometer. The vacuum corresponding to 110 degrees, where water vapor is involved, is 27.4 inches, of which 26 inches is 95 per cent.

It is well, therefore, to specify as the vacuum to be produced a given percentage of the barometric pressure; but if "the possible" as determined by the condensing water temperature is meant it should be so defined that there can be no ambiguity about it nor dispute about its interpretation.

The Cost of Power

What is the best means to determine the cost of power per kilowatt-hour or horsepower per year? The answers may be as many as there are engineers. It is quite easy to determine the cost to the satisfaction of the accounting department, but it is difficult to so assign the charges that the engineer will consider them equitable and the accounting department tolerate the numerous items involved in the system of account keeping.

The equitable distribution of charges will probably be argued by engineers for a long time, as the subject is of so much interest and a thorough knowledge of it so valuable in defending the engineer's administration in any plant. Just how far one should carry the subdivision of charges is limited by his desire to work up, enter and file the data. The chief consideration, however, should be this: How valuable are the data collected? Just as there are plants suffering from scarcity of data of their performance, so, too, are there others burdened with an excess of it. But one can hardly convince the engineers of these latter plants that they are overburdened.

The article, "The Cost of Power," on page 567 of this issue, analyzes and considers many phases of power-plant accounting, and should bring forth some good discussion.

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Soon the refrigeration plant will be cut out or the load greatly reduced. Of course, you are preparing to thoroughly inspect and overhaul the system?

⁂

Those performance curves of the Marion Station for 1913 in the Oct. 6 issue have undoubtedly convinced many that this means of record keeping is one hundred per cent. useful.

⁂

Let's see, was there not a test conducted in New York City's Hall of Records? We have waited so long for the report to become public that we almost forgot the thing.

⁂

The contractor stood before him and with loud voice and wild gesticulations guaranteed to furnish for an indefinite period a coal that would not smoke, that was free burning, whose ash would not clinker nor fuse at any conceivable temperature; that would always have less than one per cent. moisture, and whose heating value was fifteen thousand heat units for every pound. Eagerly he bent forward to sign the contract, and then—he awoke.

Correspondence

Crankpin-Bearing Record

We have a crankpin box which has been in service for the last 15 years, running 10 hours a day at 215 r.p.m., and is still doing good work. It is a brass box with the button form of babbitt. The engine cylinder has been bored out twice during the life of these brasses. I believe this is an unusual record of service for a crank bearing of any material.

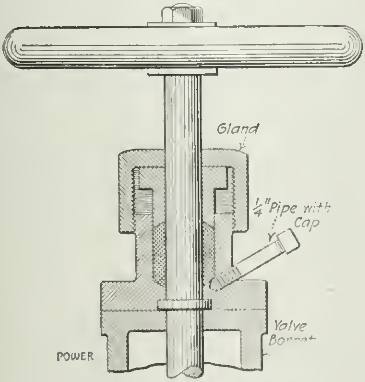
Albert Warner.

Appleton, Wis.

Valves Packed under Pressure

The illustration shows a makeshift method of doing what the valve manufacturers should do properly. All modern valves should be capable of being repacked under pressure when wide open or shut, and most manufacturers make that claim for their product. In practice, however, it is found that even though they are tight when new, they soon develop slight leaks past the sealing joint or collar and it is then almost impossible to repack them without cutting the line out.

To overcome this difficulty we drill and tap ours for a ¼-in. pipe and put in a short piece of pipe with a cap as shown. When repacking, we open the valve wide, remove the gland and old packing, take out the pipe plug and see that the hole in the stuffing-box is open. The packing can then be put in, the gland brought down on it and the plug replaced without difficulty, any leakage during the operation escaping through the hole instead of blowing out the packing.



Packing Space Vented

We have thirty or forty valves so fitted and have had no trouble in repacking them during the three or four years they have been in use. Every valve salesman claims that his valves do not need it. A very trifling increase in the cost of manufacture would save much trouble.

For packing high-pressure steam and hot-water valves, we have found the metallic packings, of which there are several on the market, much more satisfactory than fibrous packings.

John C. White.

Madison, Wis.

Cost of Operating a Vacuum Ash-Handling System*

In Mr. Ricker's letter in the issue of Sept. 15, under this title, there appears to be a confusion of the principal subject, the steam-jet operated system, of my letter in the July 7 issue, in the blower-operated system referred to in a later paragraph.

The figures I used to arrive at, 27.10 cents as the cost of handling a ton of ashes, were based on a tentative plant of a size and type suggested by the illustration in the Apr. 7 issue, hence the omission of a motor and exhauster. The cost of installation ($1800) was assumed from a desire to give the system all possible credit. The blower system, with which the cost of handling a ton of ashes amounted to 26 cents exclusive of overhead charge, served ten boilers and handled about 35 tons of ashes per day. This layout had some 300 ft. of ash pipe with three right-angle bends, which explains the large power requirement.

The costs of operation in the plants cited by Mr. Ricker are interesting and tend to prove the economy of the vacuum system of ash removal. The plant handling 40 to 50 tons per day with an annual repair cost of only $50 is particularly interesting—$50 a year would barely provide wheelbarrows in a plant handling ashes by that means and of the capacity stated.

C. O. Sandstrom.

Kansas City, Mo.

Hocking Valley Slack Coal

In the May 26 number of Power, the writer endeavored to show graphically the relationship which exists between the heat value and ash content of Hocking Valley slack coal, basing same upon the values obtained in testing something like 1800 samples of the coal in question, many of which were average monthly samples, and each of which represented 30 or more daily samples. Since that time this number has been raised to approximately 5000 samples.

As stated in the original article, all the tests were made with the highest type of apparatus for such work and by men thoroughly experienced in the work, under the supervision of the writer.

In addition to this, the laboratory has been checked many times by other laboratories using similar apparatus and to date has not been obliged to retract any figures on coal testing. In other words, the practice of this laboratory follows the general run of coal testing as advised by the Bureau of Mines and the American Society for Testing Materials with one or two important exceptions only.

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*See Apr. 7, July 7, Sept. 8, Sept. 15, 1914 issues.

In the June 30 number of Power, there appeared a criticism of the curve as published by the writer by E. R. Andrix, of Columbus, Ohio, who is of the opinion that the heat values are higher than warranted by his tests for the given ash contents. He refers to the Ohio State Geological Survey's Bulletin of 1908 as a reference authority to back up his opinion.

We are pleased to learn his views and, to make it possible to get to the bottom of this matter, believe it is best to publish the data upon which the curve in question is based. If we are at fault in our methods or manipulation, we certainly desire to be corrected and we receive such criticism in the same kindly manner in which it is advanced. Criticism is the very life of laboratory work and should be given and received as an aid to correct results in any line of endeavor.

As mentioned above, we do not adhere to the methods of the Ohio Survey in two important factors, namely, the Fineness of the Samples and the Pressure of Oxygen used in the calorimeter. We do not believe that complete combustion is possible in the long run on the coal in question if the sample is ground to 60-mesh fineness, nor if only 18-20 atmospheres of oxygen are used. We base our claim on comparative tests made in 1912 in this laboratory which we now repeat as follows:

Pressure of Oxygen Essential to Completely Burn Hocking Valley Slack Coal in the Calorimeter

1. Average of 10 cars received, June 10, 1912, Hocking Valley Slack Coal:

a. 20 atmospheres oxygen, 11,819 B.t.u., 12.03% ash.
b. 25 atmospheres oxygen, 12,489 B.t.u., 12.03% ash.
(a showed considerable unburned coal, b did not.)

2. Average of 9 cars received June 24, 1912, Hocking Valley Slack:

a. 20 atmospheres oxygen, 11,510 B.t.u., 13.65% ash.
b. 25 atmospheres oxygen, 12,222 B.t.u., 13.65% ash.
(a showed unburned coal, b did not.)

3. Average of 10 cars received June 27, 1912, Hocking Valley Slack:

a. 20 atmospheres oxygen, 12,128 B.t.u., 12.48% ash.
b. 25 atmospheres oxygen, 12,595 B.t.u., 12.48% ash.
(a showed unburned coal, b did not.)

All the above samples were ground to 100-mesh fineness.

Each B.t.u. figure given is the average of two determinations, the greatest variation in checks being 70 B.t.u.

All samples were dried at 105 deg. C., for one hour before testing.

Grinding of Samples for Calorimetric Tests

Each of the above named samples in their original form was ground to 20 mesh and halved. One-half was then ground to 60 mesh, the other half being ground to 100 mesh. The comparative behavior of the coal of two degrees of fineness was then noted in the calorimeter. Oxygen at a pressure of 25 atmospheres was used in each case.

4. Same sample as 1 above:

a. 60-mesh sample, 12,098 B.t.u.
b. 100-mesh sample, 12,441 B.t.u. Difference 343 B.t.u.
(b checks 1 above within 48 B.t.u.)

5. Same sample as 2 above:

a. 60-mesh sample, 12,008 B.t.u.
b. 100-mesh sample, 12,297 B.t.u. Difference 289 B.t.u.
(b checks No. 2 above within 75 B.t.u.)

6. Same sample as 3 above:

a. 60-mesh sample, 12,233 B.t.u.
b. 100-mesh sample, 12,560 B.t.u. Difference 327 B.t.u.
(b checks No. 3 above within 35 B.t.u.)

The Effect of both Coarse Grinding and Low-Oxygen Pressure

7. Same sample as 1 above.

a. 60-mesh, 20-atmosphere oxygen, 11,609 B.t.u.

This is 880 B.t.u. lower than 1-b above and 832 B.t.u. lower than 4-b.

8. Same sample as 2 above:

a. 60-mesh, 20-atmosphere oxygen, 11,280 B.t.u.

This is 942 B.t.u. lower than 2-b and 1017 B.t.u. lower than 5-b above.

9. Same sample as 3 above:

a. 60-mesh, 20-atmosphere oxygen, 11,888 B.t.u.

This is 707 B.t.u. lower than 3-b above and 672 B.t.u. lower than 6-b above.

In view of the above experimental results, we did not feel justified in using 60-mesh samples nor in using less than 25 atmospheres pressure of oxygen in our calorimetric tests on this coal. We adopted the use of this pressure of oxygen as our standard and 80-100 mesh as standard fineness in our grinding. As a matter of fact, fully 95 per cent. of our samples will wholly pass a 100-mesh screen, the remainder showing from 5-10 per cent. of 80-mesh particles. We do not believe there is anything to be gained by briquetting the samples of Hocking Valley Slack for calorimetric work. With reasonable care in admitting the oxygen there is little danger of loss of sample before the ignition and we find that the loose sample ignites more completely than the briquetted sample under the same conditions. We use a special type of receptacle for the coal within the calorimeter which gives us a thin layer of coal into which the oxygen penetrates uniformly. These capsules are of as wide a diameter as the construction of the bomb will permit, are made with rounded corners and are shallow. We do not find it necessary to use an asbestos pad beneath the coal when testing Hocking Valley slack.

Data for Curve

Curve: B.t.u. per Ash Content in Hocking Valley Slack

The fact that our specifications called for coal running not less than 12,000 B.t.u. per lb. accounts for the predominance of data around 12,000 B.t.u. The general average heat value of this coal for a period of three years was 12,300 B.t.u. with an ash content of 13 per cent.

Since plotting the original curve many more tests have been made, a total of over 5000, all of which conform with the original curve within reasonable variations.

In figuring the average data, we grouped the tests according to per cent. of ash, the first group being those samples which showed from 7.00 to 7.50 per cent. ash, the second 7.6 to 8.00 per cent. ash, the third from 8.10 to 8.50 per cent ash, etc.

In figuring these averages for the given ranges of ash content, we have given the proper weight for each sample according to the tonnage of coal which each sample represented. Thus 10 cars showing an average ash content of 12.50 per cent. received twice the weight or credit that 5 cars showing the same or different ash received.

DATA

Average Monthly Samples from Interurban Power Stations:

Average Monthly Samples from Interurban Power Stations

Cars Received	Ash %	B.t.u per lb	Range of Ash Content, %
60	7.33	13,229	7.0 to 7.5
58	10.69	12,617	10.6 to 11.0
57	11.39	12,580	11.1 to 11.5
55	11.96	12,811	11.6 to 12.0
61	12.22	12,385	etc., etc.
59	12.90	12,361	
56	13.28	12,298	
60	13.73	12,240	
60	14.28	12,117	
60	14.82	12,082	
57	15.22	11,965	
59	15.63	11,935	
61	16.10	11,857	
63	16.79	11,752	
57	17.37	11,560	
49	17.92	11,654	Exception to the general run
53	18.60	11,441	
55	19.62	11,367	
60	20.73	11,033	
60	22.19	10,840	
68	23.50	10,560	

Daily Samples Received at Power Stations in Detroit

Cars Received	Ash %	B.t.u per lb	Range of Ash Content, %
30	6.60	13,426	6.00 to 7.00
41	8.65	12,957	8.50 to 9.00
12	9.18	12,934	etc., etc.
43	9.25	12,902	
51	9.88	12,788	
63	9.94	12,825	
81	10.33	12,656	
112	10.78	12,627	
282	11.31	12,518	
391	11.85	12,493	
410	12.28	12,426	
488	12.80	12,357	
482	13.33	12,276	
567	13.78	12,180	
244	14.34	12,068	
260	14.78	12,038	
168	15.34	11,927	
164	15.76	11,826	
99	16.38	11,737	
77	16.74	11,722	
29	17.37	11,607	
42	17.79	11,573	
13	18.23	11,434	
10	19.28	11,054	
9	19.96	11,097	Exception
9	20.18	11,257	Exception
5	20.82	11,051	
2	24.84	10,437	
2	25.17	10,320	

The above coal was shipped from about twenty different mines located in Athens, Perry and Hocking Counties, Ohio, and is, in this section at least, known as Hocking Valley Slack. The curve therefore represents the relation between heat value and ash on this composite range of slack coal, not coal from a single mine. For this very reason we believe our figures give the general run of this coal.

If it is desirable to correct the B.t.u. figures for the moisture contained in the coal as received it is necessary to deduct in proportion to the average moisture, namely, 9.85 per cent. All the above B.t.u. figures are on the samples after drying at 105 deg. C. for a period of one hour.

We desire to emphasize the fact that we have standardized upon our calorimetric methods only after thorough study of the coal being used. For coals of another type, it is possible that other degrees of fineness and other oxygen pressures might prove of advantage. For Hocking Valley slack coal, such as we received, we believe our methods are right inasmuch as we certainly get concordant results in our work and in check work with other laboratories in this section.

However, as stated above, we welcome criticism and will be pleased to give further data, etc., and to receive in turn the opinions of others backed of course by experimental and other evidence.

Finally, it may be well to state here the fact that while using Hocking Valley slack coal at the seven power stations of this company we burned an average of 670 tons per each 24 hours over a period exceeding 3 years, another point tending to back up our notion of the relationship in question shown by this coal.

MORGAN B. SMITH,
Ch. Chem. and Combustion Engr., Detroit United Lines.
Detroit, Mich.

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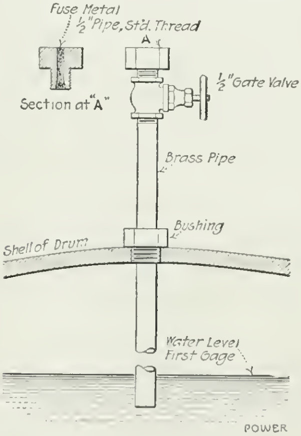
Fusible Plugs

I read with interest your editorial of Aug. 25 on fusible plugs, as I have been working on this problem lately. In many plants they are a menace; scarcely less than inoperative safety valves, because of the unjustifiable dependence placed on them. In a certain plant containing ten 300-hp. Stirling boilers, one was burned three times, and finally nearly exploded. After each burning the fusible plug was removed and thoroughly cleaned.

An idea may be formed of how hot the boiler must have been, without melting the outside alarm type of plug, when the ebonite gasket between the nozzle and nonreturn valve was burned out. I wired the fusible disk to the bulb of a high-temperature thermometer and held both before a blow-torch flame and heated them very slowly to 180 deg. F. before the metal began to soften; at 500 it melted enough to drop out. The plugs in the other boilers were tried and found to be practically the same, except one which melted at 370 deg.



FUSIBLE LOW-WATER ALARM

Even if the metal had fused it is doubtful whether any great amount of steam would have escaped on account of the many devices fastened to the pipe, including a whistle which had been given several coats of black paint, completely closing the steam orifice. The old alarms were taken out, and ones adopted as shown in the sketch. When the fusible plug blows out it makes a report like a pistol shot and the roar of the steam can be heard all over the power plant. The fusible cones to fit in the plug *A* are tested before using by touching a bare high-pressure steam pipe with them. If they do not start to fuse in a contact lasting three seconds, they are condemned and not used.

Each month when the boilers are washed and cleaned the boiler washer removes the plug and takes it to the engineer who inspects and replaces it just before steam is raised after passing a ⅜-in. round rod down through the pipe and valve into the drum to make sure the passage is clear.

The watch engineer must state in his daily log the condition of the fusible plug when received by him, and he is held directly responsible for its condition. The gate valve is locked open with a padlock and chain and only the watch engineer has a key.

Five plugs have been blown out since Apr. 1, two from no apparent cause; and the others from a burst tube, a break in the pipe above the water line, and from low water.

S. H. FARNSWORTH.

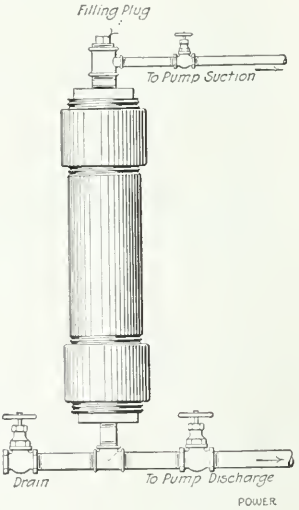
Chicago, Ill.

⁂

Experience with Graphite

The water in this locality contains much carbonate and sulphate of lime, thus causing a great deal of pitting and corroding in the drums and tubes of our water-tube boilers, and heavy scale causing many overheated tubes.

We have overcome our difficulties by installing two large settling tanks, treating the water with the proper amount of soda ash and lime and giving the tubes a thorough cleaning with a mechanical cleaner, following it up with regular graphite treatment. The pitting and corrosion have stopped, no new scale is being formed, and two boilers are doing the work of the former three.



GRAPHITE FEEDER

Feeding graphite into the suction of the boiler-feed pump as shown in the illustration, is advantageous because the graphite in passing through the pump prevents scale from forming on the valves and sleeves of the pump.

GEORGE COLLISTER.

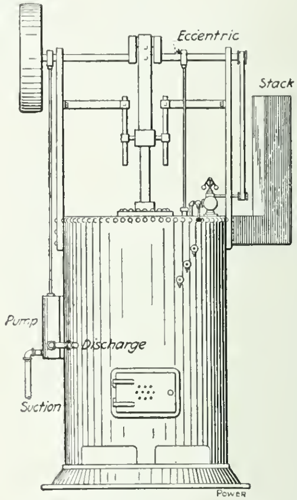
Salem, Kan.

⁂

Self-Contained Steam Plant

Much has been published recently about the unit plant of the locomobile.

Recently, I had occasion to look over some old machinery that had been in storage some thirty or more years and I unearthed a self-contained plant that showed that someone had the right idea years ago. One of the caretakers informed me that this particular device had been there for 35 years, so it's a sure old-timer.



SELF-CONTAINED STEAM PLANT

The accompanying sketch gives an idea of the general construction of the unit. The boiler is of the vertical fire-tube type. Upon its top are two standards, riveted to the shell, which support the guides and crankshaft of the engine. On one end of the shaft is a flywheel 30 in. in diameter, and 5-in. face. Set into the top of the boiler is the cylinder and valve chest of the engine, the steam pipe coming up through the head, and turning into the valve chest as shown. The steam is controlled by a throttle governor on the steam line. The exhaust passes into the smoke-stack which is taken from the top side of the boiler. To the side of the boiler is attached a pump, driven from the engine shaft by an eccentric.

While the whole is rough in construction, and in its best day probably was not able to generate over 30 hp., yet it must have been a wonder for economy at that time.

Perhaps some of the old veterans can give some interesting details about this type of steam unit.

ARTHUR D. PALMER.

Dorchester, Mass.

[This type of power plant was built during the years of 1870 to 1877 and was developed by William Baxter, and manufactured by the Colts Fire Arms Co., Hartford, Conn.—EDITOR.]

Inquiries of General Interest

The Centennial Boiler Horsepower—When and by whom was the rule first adopted for rating the evaporative horsepower of boilers on the basis of 30 lb. of water per hour raised from water fed at 100 deg. F., and evaporated into steam at 70 lb. gage pressure?

A. A. B.

The first public adoption of the unit was by the committee of judges of the Centennial Exposition, 1876, in reporting the trials of competing boilers at that exhibition, the conditions being considered by them to represent fairly average practice of that period.

Scoring on Only One Side of a Crankpin—What are the causes of a scored crankpin when only one-half of the pin is scored?

H. A. C.

Scoring or cutting may be due to disintegration of the pin or the brasses from excessive pressure per square inch or want of proper lubrication, or from dirt finding its way to the bearing surfaces. Pressure is delivered from the connecting-rod upon the same side of the crankpin at each stroke of the engine and consequently the wear and cutting will be mainly on one side of the crankpin.

Relative Loss of Head in 3-in. and 4 in. Pipe Lines—What would be the relative loss of head pumping water through a 3-in. pipe line and pumping at the same rate through a 4-in. line of the same length?

J. G. B.

For discharging the same quantity of water in a given time through pipe lines of the same length and roughness of surface, the relative loss of head from friction will be about nversely as the fifth powers of the pipe diameters: hence, the loss of head with a 3-in. pipe will be to that with a 4-in. pipe as

$$\frac{1}{(3)^5} \text{ to } \frac{1}{(4)^5}$$

or

$$\frac{1}{243} \text{ to } \frac{1}{1024}$$

.e., using a 3-in. pipe the loss will be

$$\frac{\frac{1}{243}}{\frac{1}{1024}} \text{ or } 4.17$$

times the loss using a 4-in. pipe.

Pressure Realized by Siphoning—What would be the pressure head, in feet, in the foot of the long branch of a water siphon 60 ft. below the highest point of the siphon which is 8 ft. above the level of the water that is siphoned?

M. J. K.

Neglecting pipe friction and having both branches of the siphon completely filled with water, the absolute pressure in the foot of the longer branch would be that due to 60 ft., plus the absolute pressure in the top of the siphon. As the pressure in the top of the siphon would be the pressure of the atmosphere less the pressure due to 8-ft. head in the shorter branch of the siphon, then the absolute pressure in the foot of the long branch would be the pressure head of 60 ft. plus the pressure of the atmosphere, minus the pressure head of 8 ft., i.e., the net pressure head above atmospheric pressure would be 60 — 8 = 52 ft.

When the siphon is in operation some of the atmospheric pressure employed in raising the water in the shorter branch and some of the pressure head due to the height of the longer branch would be employed in overcoming pipe friction. Hence, the effective pressure head would be reduced below 52 ft. by an amount which would be practically the same as the loss of head for the same velocity of flow through a horizontal pipe of the same roughness, size and length as the total length of the siphon.

Steam Required for Pipe Coils—How many pounds of steam per hour at 150-lb. gage pressure would have to be supplied to pipe coils containing 5000 lin.ft. of 1¼-in. pipe, the steam being admitted to the coils reduced to atmospheric pressure and discharged as condensate at that pressure, assuming the rate of transmission from the coils to the surrounding air to be 1.7 B.t.u. per hour per square foot of pipe surface per degree of difference of temperature; the surrounding atmosphere being at 70 deg F.?

R. L. Y.

A pound of steam at 100-lb. gage pressure, or about 115 lb. absolute contains 1188.8 B.t.u. above 32 deg. F Admitted to the coils reduced to atmospheric pressure it would be superheated about 80 deg., i.e., its temperature upon admission would be 212 + 80 = 292 deg. F., and it would be fair to assume that the average temperature within the coils would be 212 + 40 or 252 deg. F. Discharged as condensate at atmospheric pressure, each pound of condensate would contain 212 — 32 = 180 B.t.u. above 32 deg. F. Therefore, each pound of steam introduced at 100-lb. gage pressure would part with 1188.8 — 180 = 1008.8 B.t.u. As 2.301 lin.ft. of 1¼-in. pipe are required for 1 sq.ft. of external surface, and the average difference of temperature inside and outside of the coils would be 252 — 70 or 182 deg F., then, with a transmission factor of 1.7 B.t.u. there would be:

$$\frac{5000}{2.301} \times (182 \times 1.7) = 672{,}316+ \text{ B.t.u. required per hour.}$$

As there would be 1008.8 B.t.u. received from each pound of steam the coils, would require, per hour

$$\frac{672{,}316}{1008.8} = 666.45 \text{ lb.}$$

of steam at 100-lb. pressure.

Horsepower of Boiler—What would be the horsepower of a return-tubular boiler 44 in. diameter, 30 ft. long, containing 23 tubes 4 in. diameter by 20 ft. long?

F. J. R.

The commercial rating of a horizontal return-tubular boiler is according to the number of square feet of heating surface, allowing 10 sq.ft. per boiler-horsepower, assuming the heating surface to consist of:

(a) The surface of the shell which is exposed to the fire, plus

(b) The internal surface of all the fire tubes, plus

(c) The heating surface of the heads, which is to be taken as equivalent to the gross area of one head, less twice the cross-section area of the tubes.

The circumference of a 44-in. diameter boiler would be 44 in. × 3.1416 = 138.23 in. Assuming that one-half of the shell would be utilized as heating surface, one-half of the circumference would be

$$\frac{138.23}{2} = 69.11 \text{ in.}$$

The length being 20 + 12 = 240 in., there would be

(a) 240 × 69.11 = 16,586.4 sq.in.

of heating surface in the shell.

A 4-in. boiler tube has an internal diameter of 3.732 in., hence the internal circumference would be

3.732 × 3.1416 = 11.724 in.

Each tube being 240 in. long, the heating surface of a tube would be

11.724 × 240 = 2813.76 sq.in.,

and for 23 tubes the heating surface would be

(b) 2813.76 × 23 = 64,716.48 sq.in.

The area of one 44-in. head would be

44 × 44 × 0.7854 = 1520.5 sq.in.

Each tube being 4 in. in diameter its cross-sectional area is

4 × 4 × 0.7854 = 12.566 sq.in.,

and twice the area removed by the presence of 23 tubes would be

2 × 23 × 12.566 = 578 sq.in.

Hence the heating surface allowed for the heads is

(c) 1520.5 — 578 = 942.5.

Adding results (a), (b) and (c) gives

16,586.4 + 64,716.48 + 942.5 = 82,245.38 sq.in.,

or

$$\frac{82{,}245.38}{144} = 571.14 \text{ sq.ft. of heating surface}$$

and the boiler would be rated at

571.14 ÷ 10 = 57.1 hp.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design—I

By Charles L. Hubbard

Analysis of Problem

In the present article, and those which are to follow, it is proposed to take up the various problems which arise in the design of the power and heating equipment of a large industrial plant.

While details of construction will be considered to some extent, especial attention will be given to the "blocking out" of the general scheme. In plants of this kind, the different parts of the equipment are so related to one another that it is often difficult to decide just where to begin in making the various computations. Methods will first be given for analyzing a problem of this kind, arranging the various requirements under suitable heads, and collecting the necessary working data. After this, the various steps in design will be taken up in their proper order and applied to a practical example, which will be continued throughout the series. Each installment will treat of some particular phase of the subject and will be complete in itself, but at the same time, they will follow in logical order, and taken together, cover the ground with some considerable degree of thoroughness. This series of articles is intended for the practical operating man, and all mathematical work will be given in as simple and condensed form as possible.

General Conditions of the Problem

Let Fig. 1 be the diagram of a proposed plant for the manufacture of general machinery, in which the problem is to work out a general scheme for supplying power, light, heat and water. Certain fixed conditions will be given which must be fulfilled, but within these limits a sufficient leeway will be allowed for a consideration of various methods for accomplishing the same results.

Power—Let the power requirements in the various buildings be as follows: Main shop, 250 hp. delivered at the machines, when all are running together, 150 hp. of this to be furnished by the motors belted to line shafting and 100 hp. furnished by individual motors at the machines.

Foundry—Thirty delivered horsepower, 15 hp. belted to line shafting and 15 hp in motors direct connected to machines.

Forge Shop—Twenty-five delivered horsepower, 15 hp. belted to the line shafting and 10 hp. in direct-connected motors.

Pattern Shop—Twenty delivered horsepower, with motor belted to line shafting.

Carpenter Shop—Five delivered horsepower, with motor belted to line shafting.

The electric power is to be used throughout the plant, partly by motors belted to line shafting and partly by direct drive on individual machines. Air compressors for power hammers in the forge shop and for other purposes are to be motor driven, and are included in the general power requirements above noted.

Lighting—The plant is to be lighted by electricity generated on the premises, the requirements being as follows: The erecting space in the machine shop, foundry, forge shop, boiler and engine rooms, carpenter and paint shops and storehouses are to be lighted with arc lights, while incandescent lighting is to be used in that portion of the machine shop occupied by machine tools and benches, tool room, pattern shop, drafting room and office. In addition to the above, eight arc lights, one to be provided for outside lighting.

Heating and Ventilation—The methods of heating and ventilation employed are to be those best adapted to the various buildings and departments, both effectiveness and economy of operation being considered.

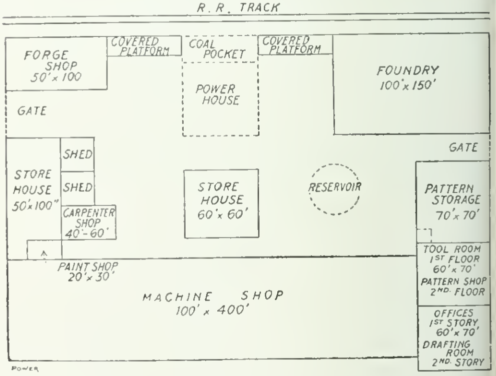


Fig. 1. Diagram of a Proposed Plant

Water Supply—Water for boiler feeding, condensing and fire protection is to be drawn from a river 500 ft. distant, the surface of which is 50 ft. below the boiler-room grade.

General Analysis

The conditions of the problem state that electrical distribution of power is to be employed, which means that the power house may be located independently of the main shop, if desired, as it will not be necessary to belt from the main engine to the line shafting. This item may have a certain bearing upon the arrangements for the handling and storage of coal, steam distribution, water supply, etc. Furthermore, a generating plant must be installed which will supply current adapted to both power and lighting, and sufficient capacity to offset the losses in transmission of mechanical energy into electrical energy and back into mechanical energy again at the machines.

The type of engine must be considered, and computations made to determine the advantages, if any, of compounding and of providing condensing apparatus for summer use. The type of boilers, mechanical stokers, forced or natural draft, coal-handling machinery, etc., are all matters to be taken up in order. The details of the electrical distribution and of lighting will not be included in the problem, but the power required for this purpose must be computed approximately to determine the capacities of the generators, engines and boiler plant.

The quantity of steam required for heating in the coldest weather must be computed and compared with the available exhaust, before determining the size of the boiler plant. The amount of ventilation, beyond a certain point, will be governed to a certain extent by the amount of exhaust steam. For example, if the supply is less than is necessary for heating purposes in the coldest weather, the amount of ventilation may be reduced at such times, and leakage be depended upon largely to supply fresh air; while if there is more exhaust steam than is required for heating, it should all, or such portion as can be profitably utilized, be employed in improving the ventilation. Before finally computing the quantity of steam required for heating and ventilating, it will of course be necessary to decide upon the type of system to be employed in each building, and the amount of fresh outside air to be supplied in the coldest weather. In determining the size of apparatus, maximum conditions must be assumed, but when computing costs of operation for determining the effect of compounding, condensing, etc., the conditions throughout the entire year must be taken into account.

Comparisons between steam requirements for heating and ventilation, and available exhaust, must be carefully made from day to day, and for different parts of the day when there are considerable changes in load, as during the lighting season. Tables or curves should be prepared showing the relation between power and heating requirements for the entire heating season. It will not usually be necessary to include each day separately, but will be sufficiently accurate for most cases if the season is divided into periods of about two weeks each and average values for these periods used in the table.

The quantity of water required by the plant will depend largely upon whether the engines are to be run condensing during the summer, and cannot be determined accurately until this point has been definitely settled. The distance the water is to be brought, and the elevation or lift, will make it necessary to force it to the plant rather than raise it by suction. To have a supply on hand at all times for fire and other purposes, it will be best to provide a storage reservoir of some form upon the premises and supply this by means of a pumping outfit located at such a point as may be necessary to reduce the suction lift to a height not exceeding 12 or 15 ft. The reservoir should hold at least a day's supply and connect with the various pumps. As the plant is to be of fireproof construction, it will only be necessary, in most cases, to provide hydrants outside and a suitable number of hose connections, with hose attached, inside. In the paint and carpenter shops, pattern shop, drafting room and offices, it would seem best to install automatic sprinklers, as these departments contain a considerable amount of inflammable material.

Available Data

The conditions of the problem already given, and a set of architect's prints of the different buildings, will furnish sufficient data for working out the designs called for. Referring to Fig. 1, the approximate location of the power house is indicated in dotted lines, the dimensions and general arrangement of this are to be determined by the engineer, and the details of construction worked out afterward by the architect.

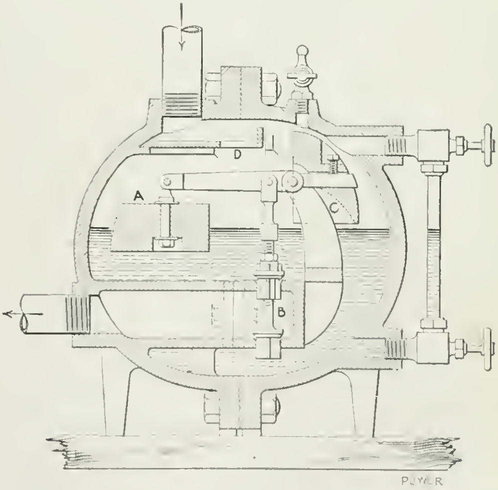
In what follows in the way of design, the chief object to be kept in view is the method of making the computations and the general order in which the different parts of the plant are taken up rather than the exact conditions assumed. These, however, will be made to follow average practice, so far as possible, and sufficient general data will be given to enable the reader to apply the methods to other conditions of a similar nature.

Thoens-Meterie Steam Trap

The Thoens-Meterie steam trap is designed for the discharge of water of condensation at any pressure from 1 to 300 lb. per sq.in.

Its working parts are made of non-corrosive material. Gravity is employed as the motive power. A weight *A*, balanced when half submerged, acting exactly like a float, opens or closes a balanced valve *B*, which is always submerged, thus allowing no escape of steam.

In appearance the body of the trap is spherical and is so designed that it can be opened without breaking the inlet or outlet connections. The half-submerged weight *A* is made of clinker-burned tile, that is indestructible by heat or water. The counterbalancing weight *C* is of cast iron. The outlet valve is accurately balanced by having both disks of exactly the same diameter. To prevent the inflowing water impinging on the half-submerged weight and thereby disturbing equilibrium, a dash-plate is placed below the inlet pipe.



Section through Thoens Meterie Steam Trap

The trap is a short distance below the vessel or coils to be drained. It is handled by James H. Fogarty, 126 Liberty St., New York City.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Boilermaker" asks the New York daily press to help subdue the noises in that city. Say, when a boiler maker complains of noise, it's pretty near time to take cognizance!

⁂

"We grieve to prick this brilliant bubble, but our [British] trade is not strangled, our hands not tied, and we are ready to fill orders for all kinds of electrical machinery," says the London "Electrical Review."

This very harsh language is a rebuke to the "Electrical World" and to Doc. Louis Bell for intimating that England is, industrially, "hors concours." Intimators, take notice.

⁂

The New York Electrical show this year frazzles all former efforts. Everything is being done by this popular juice, from resuscitation after a bichloride of mercury tablet to raising chickens and making money. (The money is made by U. Sam in his miniature mint exhibit.) And there are battleships and cows, and hair-raisers and telescribes, and shampoos and pigs, and—well, you have to be there to get it all.

⁂

Says a contemporary about the Kansas City pumping station: Trouble caused by small pieces of waste clogging the lubricators is entirely removed when the oilers use towels. Sure, but did you ever try a hard-boiled sheet or a cotton sock?

⁂

Answering the inquiry, what are the seven wonders of the world? every answer includes "electricity," says the paper. This big wonder makes us wonder how anyone could overlook it.

⁂

Some More from Samoa

There was a young man from Samoa
Who never knew what was in store
When he signed on the ship "Sarah Gore,"
With a hold full of freight for Lahore.

They set him to firing soft coal through a door
That belched heat and flames that scorched him sore,
The like of which never was known in Somoa—
Nor gages that always had trouble in store.

He never had fired before—
And he'll never again—on the "Gore."
Down went that gage near the door
As he dreamed some, and more, of Samoa.

Quick was he wakened and lifted before
The fist of the chief, who felt mighty sore
That he couldn't do murder right there on the floor.

* * * * * *

'Stead of painting the ship with his gore,
They lowered him, pointing to shore—
He's now on his way—to Samoa.

⁂

"What the public wants is a window through which it can look into the affairs of public service corporations," says a traction man.

Yes, and just about the time Public is giving it the once-over, the corporation usually jambs the sash down on his fingers or has him pinched for a Peeping Tom.

⁂

Among the American delicacies now finding favor among the nations of Ceylon are canned fish, face powder and a growing respect for our manufacturers. Looks like the Province of Sabaragamuwa had tipped off the rest of the island to our merits.

⁂

Rep. Nelson of Wisconsin told the House he has ever been a "bloodhound on the trail of the octopus." Must be like one of those sea dogs we saw in Milwaukee diving off a jackknife bridge into the canal after catfish with a diving suit on. Octopuses act real queer if you sit up late enough to watch 'em come up on the bank. It's the only way you can trail 'em.

⁂

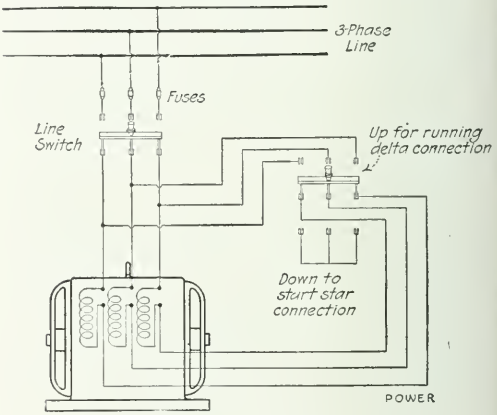
"Japs Have Taken Yap."—Headline.

And what have the Yaps taken—to the tall timber? We can spare a few yaps who, if they could have the running of the plant, would do it so much better than the chief. Somehow, they never get a chance to do much else than yap.

Delta-Star Starting for Induction Motors

By A. L. Temple

There are many cases where the use of an expensive auto-starter for an induction motor of medium size that is started only once a day is a considerable burden of expense and one that the operating man would like to get around. The use of starting and running fused circuits with double-throw switches, which has caused so much discussion with underwriters' inspectors, was devised for this purpose and in many cases works well, if allowed. Another means which seems to work equally as well and one against which the underwriters are not so strenuously opposed, is the delta-star connection of motor-stator windings. The connections for this arrangement are shown in the accompanying illustration. It is required that the phase terminals of the motor windings be brought out to some convenient point so that connections can be made to the line circuits; this, however, is not a serious drawback to the operator, who has some idea of how the stator winding is made up. In case new motors are to be purchased, there is a type on the market that has special arrangements for bringing out the phase terminals.


3-Phase Line
Fuses
Line Switch
Up for running delta connection
Down to start star connection
POWER

Delta-Star Starting Connections

The working of this arrangement is as follows: With the double-throw switch down, the windings are connected in star and when up in delta. When connected in star the voltage per phase on the motor windings is $1 \div \sqrt{3} = 58$ per cent. of the line voltage, sufficiently low so that the motor starts without an excessive starting current, which is about 1½ times that at full load. Since the starting torque of the induction motor is proportional to the square of the starting voltage, the starting torque for the star-delta method is 33 per cent. of that for the full-line voltage.

The size of switches to satisfy the underwriters when using this means should be as follows: A switch of 30 amp. for ½- to 7½-hp. motors, 100 amp. for 25- to 35-hp. motors and 200 amp. for 40- to 50-hp. motors.

The main objection to this method is lack of starting torque in comparison with the auto-starter.

Freeing the Final Stages of Steam Turbines

By F. R. Low

SYNOPSIS—The principal hindrance in building a steam turbine of very large capacity arises from the immense volume which the steam takes at the low terminal pressures attained and the difficulty of providing area enough in the final blades for this steam to get through without too much residual velocity. The article shows some late attempts of the inventors to meet this situation.

⁂

One of the factors which limit the capacity of steam turbines is the difficulty of providing for the great volume which the steam assumes in the final stages.

This volume increases at a rapid rate as the pressures diminish to those existing in the final stages with the high vacuums now sought. A pound of dry-saturated steam at an absolute pressure of 230 lb. occupies a volume of about 2 cu.ft. In a vacuum this increases, in round numbers, as follows:

Vacuum in Inches of Mercury	Absolute Pressure In. Mercury	Volume. Cu.Ft. per Lb.	Relative Volume, 2.004 = 1
20	10	75	37
22	8	92	46
24	6	120	60
26	4	176	88
28	2	339	169
29	1	654	326
29.5	0.5	1257	627

If the steam, at 230 lb. absolute and dry-saturated to start with, were still dry-saturated after being worked to a vacuum of 29.5 in., its final would be 627 times its initial volume. This is modified considerably by the fact that the initial volume will be greater if superheat is used and that a considerable percentage of the steam is condensed during expansion, but not so much as would be if the expansion were adiabatic on account of the carrying of some heat to the lower stages by conduction and to the generation of heat by eddy and friction. The accompanying table gives the approximate volumes in cubic feet for steam of various initial pressures and degrees of superheat expanded to the pressure corresponding to 85 degrees F., 0.594 pound per square inch.

INITIAL AND FINAL VOLUMES AND RATIOS OF EXPANSION OF STEAM EXPANDED ADIABATICALLY TO 85 DEG. F.

Pressure Lb. per Sq.In. Absolute	Superheat, Deg. Fahrenheit 0	50	100	150	200	250	
100	4.43	4.79	5.14	5.47	5.80	6.12	Initial volume
	427	437	445	453	460	467	Final volume
	96	91	87	83	79	76	Ratio of expansion
120	3.73	4.04	4.33	4.62	4.89	5.17	Initial volume
	423	433	441	449	456	463	Final volume
	113	107	102	97	93	90	Ratio of expansion
140	3.22	3.49	3.75	4.00	4.24	4.48	Initial volume
	419	429	438	445	453	459	Final volume
	130	123	117	111	107	102	Ratio of expansion
160	2.83	3.07	3.30	3.53	3.74	3.95	Initial volume
	416	426	435	442	450	463	Final volume
	147	139	132	125	120	117	Ratio of expansion
180	2.53	2.75	2.96	3.16	3.35	3.54	Initial volume
	414	424	432	440	447	454	Final volume
	164	154	146	139	133	128	Ratio of expansion
200	2.29	2.49	2.68	2.86	3.04	3.21	Initial volume
	411	421	430	437	445	451	Final volume
	180	169	160	153	146	140	Ratio of expansion
220	209	228	2.45	2.62	2.78	2.94	Initial volume
	409	419	428	435	442	449	Final volume
	195	183	175	166	159	152	Ratio of expansion
210	192	2.09	2.26	2.42	2.57	2.71	Initial volume
	407	418	426	434	441	447	Final volume
	212	200	189	179	172	165	Ratio of expansion
260	1.78	1.91	2.10	221	239	2.52	Initial volume
	405	416	421	432	439	445	Final volume
	228	217	202	196	183	180	Ratio of expansion

Of the group of three figures for each initial condition of pressure and superheat, the first is the initial volume in cubic feet per pound: the second, the volume after adiabatic expansion to 85 degrees F., and the last, found by dividing the second value by the first, the ratio of expansion or the number of times the final volume is as great as the initial. Notice that the *higher* the initial pressure or superheat, the smaller the final volume. This is because, starting with more pressure or superheat, the steam does more work with consequently greater heat conversion and condensation, a less percentage of it being steam even with its higher initial heat content than in the case of the lower initial pressure or temperature.

These figures are theoretical, based on adiabatic expansion. As the result of all the departures from this mode of expansion—except the inconsiderable loss due to radiation—is to carry the heat to the lower stages and add it as heat to the acting steam itself, the actual final volumes and ratios of expansion are even greater than those shown here.

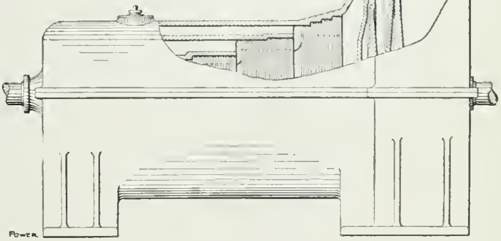


Fig. 1. R. H. Rice's Suggestion of Enlarged Final Disks

Allowing the final volume of a pound to be 450 cu.ft. and the steam rate 12 lb. per kilowatt-hour, a turbine generating 30,000 kw. would discharge

$$\frac{450 \times 12 \times 30{,}000}{60 \times 60} = 45{,}000 \textit{ cu.ft. per sec.}$$

In order that the efficiency of the later stages may not be impaired, this great volume must flow through the blades with a velocity not greatly exceeding twice their own peripheral speed. This speed is limited by considerations of centrifugal force and quiet running in the direct-connected generator as well as in the turbine itself. At the same time the size of the passage, determined by the length of the blades, is restricted by the mechanical difficulties attending the use of blades of great length, and by the fact that if the blade is too great a proportion of the radius, there will be too great a discrepancy between its root and tip speeds, so that if the ratio between the velocity of the steam and that of the middle of the blade is correct, it will be too low for the tip and too high for the root.

The struggle is therefore to get greater peripheral velocity for the final blades and greater section through them in order to keep the ratio between the steam and blade velocity down to the proper point.

It is the custom of all builders of reaction turbines that are designed for 28-in. vacuum, or better, to change the angles of the last one or few rows of blades, increasing the angle with the direction of motion, say, using an angle of 10 deg. instead of 20. Fig. 6, and by this means doubling the area of passage way at some sacrifice of hydraulic efficiency. The blade thus produced is often referred to as the "wing" blade. It is understood, of course, such a machine designed for high vacuum, 29-in. for example, the last row of blades may require to have nearly double the blade area of the preceding row.

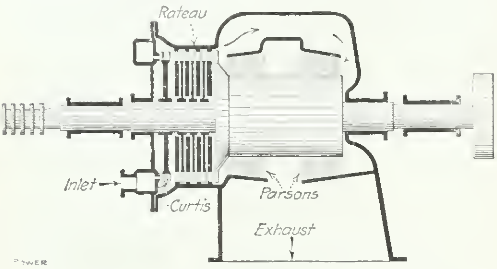


FIG. 2. PAPE'S TURBINE WITH VELOCITY PRESSURE AND REACTION STAGES

Richard H. Rice, manager of the General Electric Co. at Lynn, Mass., in a recent patent attacks the problem by increasing the diameter of the final element, as shown in Fig. 1, gaining thus both peripheral speed and greater area through the blades. He suggests one or more impulse wheels each carrying preferably but a single row of buckets, operated in the usual way with nozzles located in the diaphragms which inclose such stages. These impulse wheels or disks can be made of sufficient diameter to give a peripheral speed approximately correct for the best efficiency; that is to say, about one-half of the velocity with which the steam flows. Moreover, the impulse wheels require no balancing drum or dummy pistons and are much lighter than the blade-carrying drum would be.

Wilhelm Pape, of Charlottenburg, Germany, has just assigned to the General Electric Co. a patent for the ar-

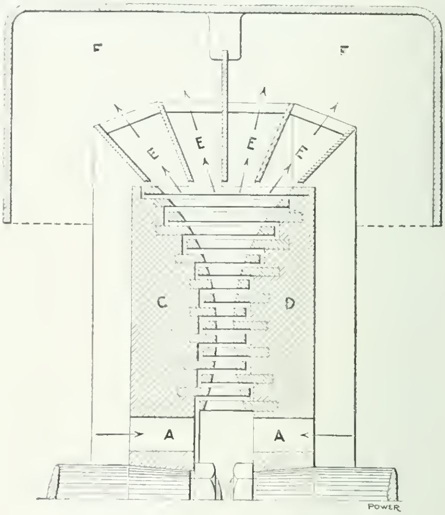


FIG. 4. LUNGSTRÖM'S DIFFUSER

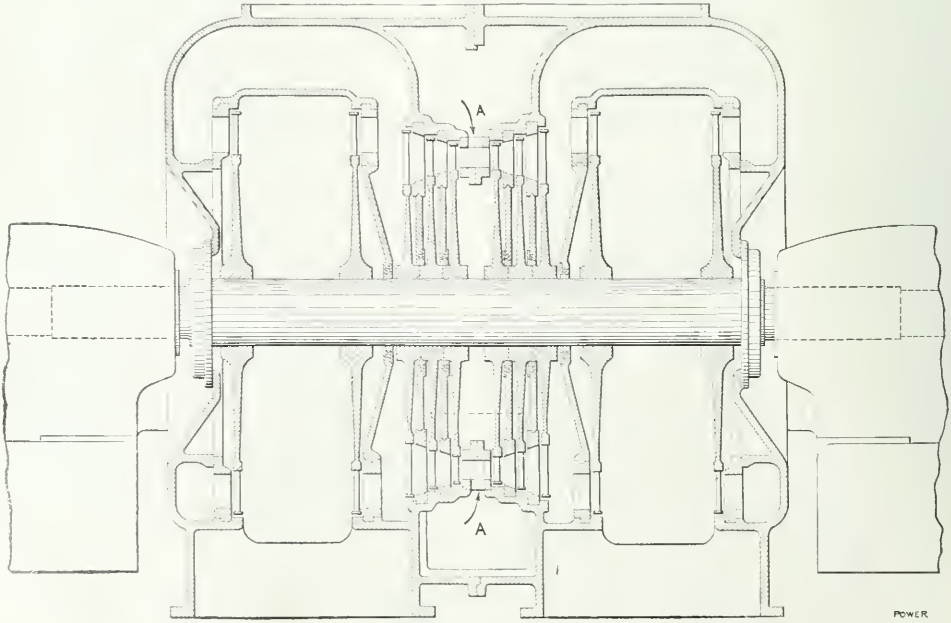


FIG. 3. JUNGGREN'S LOW-PRESSURE TURBINE WITH TWO-WAY EXHAUST

rangement shown in Fig. 2, in which all three types of blading are used, initially a high-pressure velocity stage (Curtis); next, pure pressure-impulse stages (Rateau), and finally, reaction stages (Parsons). The engraving shows the reaction element as double-flow, exhausting in the center. This eliminates the necessity for balancing plates or dummies, but the patent specifications show it both single- and double-flow. Due to the use of the intermediate pressure stages, the reaction stages may be of liberal proportions, especially as regards the diameter at the inlet, and the total number of such stages can be made relatively small. We mentioned in 1910 a turbine comprising these three types of blading said to have been designed by Prof. Beluzzo and built by Gadda Finzi & Co., of Milan.

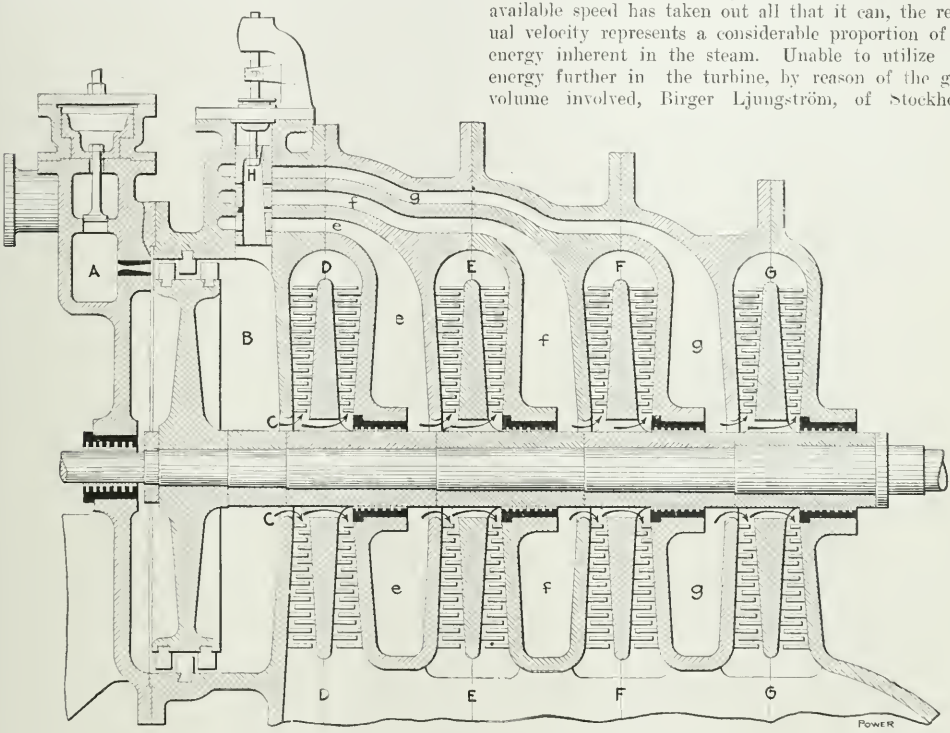


Fig. 5. London's Secondary-Stage Turbine

Since 1907 the Westinghouse Machine Co. has built turbines for certain ranges of capacity, having an impulse element for the high-pressure followed by a single-flow reaction element, this again followed by a double-flow reaction element, the latter expanding from approximately atmospheric pressure to that of the condenser, all this for the purpose of being able to handle the rapidly increasing volume of steam in the low-pressure range.

Oscar Junggren, turbine designer of the General Electric Co., at Schenectady, has patented the arrangement shown in Fig. 3 for low-pressure turbines. After leading the steam, which enters at *AA*, through the first few stages of a divided-flow turbine, it is directed at each end of such turbine against bucket wheels operated in parallel so that without any excessive increase in the diameter of each wheel or unwieldy lengthening of the buckets, the available bucket area is doubled in that stage. In effect, it amounts to another division of each subdivision of the divided-flow turbine, so that during the concluding portions of its passage the steam has four parallel paths instead of two.

In order to get the steam through the final stage, it must pass with such velocity that after the wheel at the available speed has taken out all that it can, the residual velocity represents a considerable proportion of the energy inherent in the steam. Unable to utilize this energy further in the turbine, by reason of the great volume involved, Birger Ljungström, of Stockholm, Sweden, uses it to bat back the pressure beyond the final wheel, and thus to enable the final expansion to extend to a pressure lower than that which exists in the condenser itself. In Fig. 4, reproduced from a patent recently issued to Mr. Ljungström, the steam entering at *AA* flows through the blades, which are fashioned so as to form a nozzle adapted to the ratio of expansion for which the turbine is designed. The disk *C* to which one set of blades is attached revolves in one direction, and the disk *D* holding the alternate blades, in the other

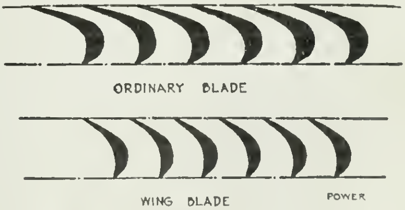


Fig. 6. Comparison of Blade Angles

direction. As the steam leaves the last blade it is discharged at considerable velocity into the diffuser passages *EEEE*, repelling the pressure which exists in the spaces *FF* connected to the condenser. The pressure in the last blade may, therefore, become by expansion less than that which the condenser is able to maintain.

W. J. A. London, of Manchester, England, runs a lot of secondary reaction stages in parallel behind a single initial Curtis velocity stage wheel. Steam enters at *A*, Fig. 5, through a series of nozzles of which the governor opens more or less, letting in more or less steam according to the load. The steam discharged from the Curtis blading passes into the chamber *B*, and thence through the passage *C* to the reaction element *D*. As the amount of steam admitted becomes so great that this reaction element cannot take it all away and pressure commences to build up in the chamber *B*, the valve *H* is lifted, opening successively the passages *e*, *f* and *g*, permitting the escape of the steam to the elements *E*, *F* and *G*, which are automatically brought into action according to the amount of steam flowing.

* * *

Status of Automatic Stokers[*]

BY R. J. S. PIGGOTT

The principal considerations in the design of a stoker are:
Coking of green coal,
Adequate mixture and heating of volatile matter with air,
Burning of fixed carbon,
Disposal and dumping of ash and clinker; other points, only less important than the first four are,
Prevention of sifting,
Prevention of clinker adherence to brickwork and stoker parts.

OVERFEED STOKERS

The principal overfeed types of stokers are the Roney, Wilkinson, Wetzel, Murphy, Model, Detroit and Lehigh. The Roney step grate has renewable fingers as a grate surface; the Wilkinson, hollow stepped bars from top to bottom of the furnace; the Wetzel has bars from top to bottom of the furnace, with lugs cast on the sides to retain the coal; the Murphy, Model and Detroit are almost alike, having bars similar to the Wetzel, but two grates set opposite to each other in the form of a "V" with a coking arch over the whole. In addition, a set of clinker rolls or crushers is added at the bottom of the "V."

In all of these stokers, coal is pushed in at the top of the slope and coked by the aid of a firebrick arch, progressing down by the motions of the grate bars, aided by gravity. In all, the upper portion of the bars is arranged to retain the uncoked fine coal upon the grates, changing to larger and freer openings in the lower two-thirds, where the coal has fused into larger bodies, and the combustion is chiefly that of fixed carbon. The clinker is collected at the bottom and there crushed by rolls or dumped.

The coking action is confined to a zone at the top of the furnace and must necessarily generate a copious volume of hydrocarbon gases which cannot be adequately and intimately mixed with air; because the green coal packs closely and is almost impervious to air, under slight differences of pressure; so that the air for burning the volatile matter must be supplied either from the air openings in the arch, or from excess air admitted through the lower portion of the grates. In the short distances from the grate to the tubes, except in such boiler settings as the Stirling, the time between leaving the grate and reaching the tubes is too short to allow thorough mixing of the gas and air; so that cooling occurs before the gases can mix and burn, and incomplete combustion results.

The burning of fixed carbon is easy, as coking leaves it more or less open and porous, and the fusion of siftings into larger masses allows plenty of air to be admitted. In fact, the usual operation permits a considerable excess of air at this portion of the grate. The evidence is to be found in the smoky red flame passing up through the tubes over the coking zone, changing through yellow to blue and finally to the clear and almost flameless fire indicating excess air at the dump-grate end.

The accumulation of excessive clinker must be prevented by slicing and periodic dumping; if left for long periods to burn out all combustible, the clinker is liable to be large and hard to dislodge. If dumped at short intervals, the combustible is not all burned out. The roll crusher employed in the V-types is apt to give trouble from adhering clinker and refusal to grip large clinkers, necessitating excessive barring.

Sifting to the extent of 5 to 8 per cent. occurs in all overfeed stokers, depending on the air space allowed and the length of time the stoker has been in use. In all the overfeed stokers, since the hot fixed carbon combustion occurs directly on the grates, burning of iron is considerable, especially with high sulphur coals. The pyrites and sulphur have a fluxing action on the iron. Once the clinker gets down to the iron, and the bar becomes overheated, the whole bar may melt and run down in a few minutes, by what appears to be a catalytic action.

Any of these stokers will operate with fair efficiency and little trouble from clinker and burning, if operated at their proper capacity, as rated in pounds per square foot of grate area. At the present time it is considered good practice to provide sufficient stoker capacity to operate the boilers at 200 per cent. of rating continuously.

CHAIN-GRATE STOKERS

The chain grate group, such as the Green, Babcock & Wilcox, Illinois, Coxe, Mackenzie and Laclede constitute a successful type for the burning of a certain class of bituminous coal, namely, high volatile (30 to 40 per cent.) and high ash (10 to 20 per cent.). They are subject to many of the slope-grate overfeed drawbacks, but have additional advantages. Coking occurs in a zone at the entrance to the stoker, but as the coking arch is much longer than for the slope-grate types, the mixing of air and volatile matter is more effective, and less loss due to incomplete combustion of gases results. The burning of fixed carbon is accomplished in the same way as on the slope-grate overfeeds. Clinker troubles are reduced, as the grates are entirely cleared of ash and clinker, and cooled by the return on the under side, once every complete revolution of the grate.

The ash and clinker dump automatically at the water or air-back, and no hand slicing is necessary. Labor is therefore less than for the slope-grate overfeeds. One stoker operator is required to four Roney type stokers of 500 to 600 hp. rating, and one coal passer for about every five or six stokers. One stoker operator and one coal passer can handle about ten chain grates.

The weight of the chain grate is the highest of any type. For instance, a Roney stoker for a 600-hp. B. & W. boiler, 12 ft. 6 in. width of furnace, weighs 30,000 lb.; a Green type-L chain grate for the same furnace weighs 80,000 lb.; the Illinois stokers weigh from 60,000 to 82,000 lb., depending on the type, and a Taylor underfeed with extension grates, 32,000 lb.

The forcing capacity of the chain grates is somewhat higher than that of the slope grate overfeeds, except the Wilkinson and Lehigh, since forced draft can be employed as well as natural draft; however, it has not been very successful to use forced draft with certain kinds of coal. The maximum boiler rating obtainable ordinarily with the Roney or Murphy types is 190 per cent. of rating, with a combustion per square foot of grate of not over 35 to 38 lb. of coal per hour. General practice does not exceed 150 to 175 per cent. of rating. This limitation is partly on account of natural draft, and partly maintenance. Natural draft higher than 1.5 in. of water is practically out of the question, and burning of the grates at higher rates of driving becomes excessive.

The chain grates are generally larger in area for the same boiler, and the forcing capacity will reach 260 per cent. of boiler rating, with combustion rates up to 45 to 48 lb. These results apply chiefly to the use of coal suited to the stoker. With low ash coals at these rates of driving, the grates become overheated, and breakage, with the attendant high maintenance and unreliability, is sure to result.

For the burning of such coals as described, the chain grate gives eminently satisfactory results; but for low ash coals it is practically a failure.

UNDERFEED STOKERS

The underfeeds are represented by the Taylor, Riley, Westinghouse, Jones and American. The Jones has usually a single horizontal retort per furnace, spreading coal by a ram, from the center to the sides of the furnace; there may be two or more retorts for wide furnaces. It has only recently been provided with means for dumping into an ashpit.

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[*] From the report of the Committee on Power Generation, presented before the Engineering Association of the American Electric Railway Association at Atlantic City, Oct. 12 to 16, 1914.

The American has a single central horizontal retort, and movable grates somewhat similar to the Murphy stoker, with dump plates at each side of the furnace. The Taylor, Riley and Westinghouse have several retorts per furnace, according to the width of the setting. The retorts are alternated with rows of tuyeres for supplying the air and the whole is set at an angle of 20 to 25 deg., using gravity to aid the working of the clinker and ash to the back of the furnace. The green coal is fed from under the surface of the fire by the rams: it spreads over the tuyeres through which the air is forced, and as it approaches the surface of the fire is coked by the burning of fixed carbon and volatile matter in the upper layer. The volatile gases, closely mixed with the air, pass through the incandescent coke before reaching the combustion chamber. The process has radical advantages over the overfeed method; first, because green coal or only partially coked coal covers the tuyeres, so that burning of the iron is practically eliminated; second, there is distillation of the volatile matter over nearly the whole area of the furnace; third, immediate and intimate mixture of the whole air supply and volatile matter while still in the coal bed; fourth, passage of mixed volatile and air through the hottest zone of the fire (burning coke and gases) before reaching the furnace; and fifth, the elimination of all arches. The essential conditions for perfect combustion of volatile matter are intimate mixture with air, and high temperature; the underfeed method meets these conditions very well. The fixed carbon is not quite completely burned in this process, so that a short section, termed an extension grate, is added to the bottom of the tuyere and retort section, and the combustion of fixed carbon is completed on these grates in the same manner as an overfeed. Finally the clinker arrives in the dump plates (in the Taylor) or is expelled by continuous dumping and crushing devices (a moving extension grate and apron in the Westinghouse, and a moving apron in the Riley).

The Westinghouse stoker differs from the Taylor very little in general design, except in the use of the continuous dumping device, and an air-cooled bridge supporting the front wall. The Riley stoker differs from the other two in moving the tuyeres bodily and in having more overfeed effect. The underfeed stokers are essentially forced draft stokers, as they operate with restricted air openings and very deep fires. The Riley and Westinghouse can be operated with natural draft of 80 to 90 per cent. of rating, but this is not generally desirable. On the Taylor stoker the fires run from two to four feet thick, depending on the rate of driving, whereas the Riley, having more overfeed effect, seldom exceeds one to two feet. The forcing capacity is enormous, reaching as much of 400 per cent. of rating at 80 to 85 lb. per square foot of grate. Three hundred per cent. of rating is readily obtained continuously at from 60 to 65 lb. of coal per square foot of grate. One man can operate ten or twelve stokers: siftings are negligible, amounting to 0.2 per cent. or less, requiring clearing of the windbox and retorts about once a month. The brickwork at high ratings suffers somewhat from the adherence of clinkers to the side walls and the bridge wall, but there are no arches required, and arches are the most expensive and troublesome of all brickwork in the furnace.

Thirty-Fifth Anniversary of Electric Lighting

Oct. 21 will commemorate the 35th anniversary of the invention of the incandescent lamp by Thomas A. Edison. This day in 1879 may be said, broadly speaking, to mark the birth of electric lighting. Arc lamps had been in use some years previous but only a few were then employed, for searchlights, to light theaters, parks, street corners and similar public places. The universal lighting of both public buildings as well as private dwellings by electricity through small units became a dream realized only when Edison first successfully made his electric filament bulb glow in his laboratory at Menlo Park, N. J., 35 years ago.

In 1880 an employee of the Edison factory carried all the electric incandescent lamps in the world from Menlo Park to New York City in a market basket. A year later it was considered a wonderful feat when the small factory turned out a thousand lamps a day. Today, the great Edison lamp factory at Harrison turns out 35,000 lamps an hour and will have made in all more than 500,000,000 lamps during the period of the phenomenal progress of electric lighting up to the present time.

Dr. Charles P. Steinmetz, the wizard of electricity and chief consulting engineer of the General Electric Co., in giving the essence of his appreciation of Mr. Edison, said:

"The first time I met Edison was in 1893, at the International Electrical Congress in Chicago. Mr. Eickemeyer introduced me to him, and Edison, jokingly pointing at me, said, 'Pure theory'; pointing at Eickemeyer, 'Theory and practice,' and at himself, 'Pure practice.' This is the attitude Edison has always taken, declaring himself a mere practical man. Some have expanded on this and so created the popular belief that Edison does not know anything about theory and science, but merely experiments and tries everything he or anybody else can think of. There is nothing more untrue than this, and Edison probably never made an experiment or tried something where he did not have a good theoretical reason that would justify the trial even from a strictly scientific standpoint."

We are all more or less familiar with the events of the romantic life of Edison, the boy, who only really went to public school three months, was given up by his teachers in despair because he was always at the foot of the class, was taught by his mother; installed a laboratory in the cellar of his home; started in business as a newsboy on trains of the Grand Trunk to get money for scientific books and equipment for his laboratory; installed another laboratory in a baggage car of the train and was thrown off because one of his dubious experiments set fire to the car; became a telegraph operator; began to invent and became the greatest inventor of the age, having taken out no fewer than 1328 separate patents from 1869 up to the summer of 1910. The height of his activity was in 1882 when 141 patents were applied for.

The events connected with the invention of the electric incandescent lamp are especially interesting.

In the search for the right material that should make the incandescent lamp a feasible, profitable commercial proposition, all kinds of pastes were tried as bases for dependable carbon filament; also cotton thread, paper and anything that would carbonize readily and hang together as a "filament" when the electricity was turned on.

For nearly 10 years the Edison lamp was made with bamboo filaments; and to that lamp must be attributed in a large degree the marvelous development of electric lighting and power all over the world, as well as the creation of the modern central-station industry, which in the United States alone represents an investment of over $2,500,000,000 and annual earnings of over $350,000,000. Even as late as 1908, a few special types of Edison bamboo lamps were being made.

Paralleling the carbon filament lamps of bamboo, there appeared the "squirted" filament, employing carbonized cellulose, and a great many lamps for a number of years were of this type. Another advance was embodied in lamps still of the carbon type, in which the filaments were strengthened by such substances as would justify calling them "metallized." In particular, the metal tantalum seemed to stand out from the rest of the group, but it was never a strong competitor of the carbon lamp. The solution was soon found in tungsten, a metal tried as far back as the earlier days of Edison, but not then available under the practical conditions of its production and use.

The introduction and general adoption of the Mazda tungsten lamp has been literally nothing short of a revolution in the art of interior illumination, with a correspondingly tremendous effect on exterior lighting. Working down from a consumption of four or five watts per candlepower in carbon filament lamps to the standard a few years ago of 3.10 watts per candlepower, the Mazda lamp has brought that down in about five years to 1.25 watts; while in the larger sizes of gas-filled lamps, the reduction in current consumption has reached the low point of a half-watt per candle.

The intimate history of the birth of the electric incandescent lamp is best told by W. H. Meadowcroft, who was associated with Edison when he produced the lamp:

"Business was getting fairly well under way when I assumed my duties at 65 Fifth Ave., New York. The back parlor was used by Major Eaton as his office; on the second floor was Charles L. Clarke, the chief engineer with H. M. Byllesby at the drafting board; Edward H. Johnson had part of the same floor with E. T. Greenfield as the foreman of his wiring gang; and a good part of the third floor was used by Mr. Edison as his office and headquarters, with Samuel Insull, recently from London, installed as secretary. On the third floor there was also the patent department, where Col. Dyer and several assistants were kept busy day and night making applications for patents on the flood of inventions that was constantly pouring in.

"Those were tremendous days for Mr. Edison. Besides the enormous amount of work entailed by the operations of his manufacturing shops, he was elaborating the engineering plans for the first central station in New York City, covering carefully every detail; he was turning out several new inventions every day, and helping the Board of Fire Underwriters formulate rules for the new art of incandescent lighting. He was also working on the innumerable details relating to isolated electric lighting plants, for which there was beginning to be a demand. He was directing the engineering and construction work of his electric railway out at Menlo Park, besides directing the policy of the company with the far-sightedness that experience has long since justified. He was working about twenty hours a day at this time, and how he ever got through so much work and accomplished so much is a mystery to me even at this day. He seemed to be utterly oblivious of the every day things of life. When he seemed to need new clothes, Mr. Insull would order them and have them delivered to Mrs. Edison. When they arrived she would wait until he had gone to bed and then change all his things over from the old suit into the pockets of the new one and leave that where he had left the old suit. He would put it on the next morning and was likely to go down to the machine works or elsewhere and get the new clothes covered with oil or chemicals.

"The selling price of lamps in the early days was 40c. each. It cost over a dollar to make them, and the financial men were worried. They couldn't see any further, but Mr. Edison did. He said in effect: 'Give me an exclusive license to manufacture during the life of the patents and I will agree to supply all the lamps you need at 40c. each.' They jumped at the chance and the contract was made. Mr. Edison lost money steadily for three years, but owing to improvements in manufacture and to the rapid development of the business, he made more money in the fourth year than he had lost in the three preceding years."

⁂

New York Electrical Show

The New York Electrical Exposition and Motor Show opened at the Grand Central Palace on Oct. 7 and closed on Oct. 17. The attendance was large. About a hundred companies and societies were the exhibitors.

The United States Government had a number of noteworthy features. The various uses to which electricity is being put in the manufacture of cartridges was shown in an exhibit from the government arsenal at Frankford, Penn. The different processes were demonstrated, from the drawing of the brass shell to the loading and fixing of the steel-jacketed bullet. An interesting piece of apparatus of the army exhibit was a hand-operated generator for use by the signal corps. This machine is operated by two men and supplies sufficient energy for a field wireless outfit. Navigating appliances, steering devices and a signal system make up part of the naval exhibit. The wireless equipment of a ship-of-war was demonstrated by a class from the Brooklyn Navy Yard. What is left of the lighting generator used on the United States ship "Maine," which was destroyed in Havana harbor, was also on display. The Treasury Department had a fully equipped mint from the United States establishment in Philadelphia, showing the whole process of coin production from the melting furnace to the stamping and weighing machines.

Among the commercial and industrial booths were the Edison Electric Illuminating Co. of Brooklyn, the New York & Queens Electric Light & Power Co., the New York Edison Co., and the United Electric & Power Co. The Westinghouse Electric & Manufacturing Co. and the General Electric Co. and its affiliated concerns were also well represented. Numerous other manufacturing companies had booths, and practically every phase of the electrical industry was represented in one way or another.

⁂

Denies International Power Co. Is Insolvent

Joseph H. Hoadley, formerly president of the International Power Company, denies the insolvency of that corporation in an eighty page affidavit presented to Chancellor Walker at Trenton, N. J., on Oct. 6. He insists that the assets exceed the liabilities by at least $3,000,000 and argues that a receiver should not be appointed.

Mr. Hoadley denies that he speculated in the stock of the company, but admits that about twelve years ago he did buy and sell the stock with a view of creating a market for it and maintaining the price. He insists, however, that he was acting under the authority of the directors for the company itself.

Admitting that numerous changes had been made in the books of the company last December, Mr. Hoadley asserts that the alterations were merely corrections designed to present the true condition of the company's affairs, and were not designed to make it fraudulently appear that the company was indebted to him instead of his being heavily indebted to the company. He says he never has pressed the company for settlement of a claim of $50,000 which he holds against it.

Mr. Hoadley explains that the reason for his retirement as a director of the company was to give the board entire freedom to act for the benefit of the company, even though it should involve bringing a suit against him personally. Counsel for Henry W. Bull, who is fighting Mr. Hoadley, intimated that the new board would be as completely under the domination of Mr. Hoadley as the old board.

Chancellor Walker said he would give both sides further opportunity to present evidence.

⁂

Water-Hammer Ruptured Valve Bonnet

A gate valve bonnet ruptured on a 15-in. underground main steam line along Dey St. between Church St. and Broadway, New York City, Tuesday morning, Oct. 6, just before 7 o'clock.

It appears that the valve had been closed in order to make some repairs to the line beyond and was being opened at the time the failure occurred. The valve bonnet was split at right angles to the line, showing signs of water-hammer. As the pressure carried is about 90 lb., the force of the blow was terrific and the escape of steam through the valve box was so rapid that the workmen who were operating the valve were unable to escape before being severely scalded about the hands and face. The pipe line is a part of the steam distributing system of the New York Steam Co., which supplies steam heat for numerous large buildings in that section of the city. Prompt action on the part of the company restored the service in a short time.

⁂

Electric-Plant Heater Explodes

A feed-water heater in the city electric light plant of Newark, Ohio, exploded at about 7 o'clock p.m., Oct. 1, and the body of the heater was projected through the roof. Although the engineer and fireman were both in the room at the time neither one was injured. The heater had been in use more than 20 years, and as the feed water is extremely bad it is likely that the inside of the piping had become so scaled up that excessive pressure was necessary to force the water through.

⁂

Revolts against Electric-Light Contract

C. L. Wooldridge, superintendent of buildings, Pittsburgh, Penn., is preparing estimates of the cost of establishing plants in at least five school buildings to make their own power. The board of public education, lighting most of its 132 school buildings with electricity, and using it liberally in many buildings for operating machinery in the shops, considers it is one of the largest patrons of the Allegheny County Light Co. in the city, but has been unable to obtain a reduction in the price below 5c. a kilowatt-hour for light, and 3 to 2½c. a kilowatt hour for power.

The principal objection voiced by board members and Carl M. McKee, superintendent of supplies, through whom the contracts are made, is that, in fixing rates, each school is considered as a unit and charged separately, whereas the board has been insisting that the entire school system be considered as a unit and charge made accordingly.

⁂

Bakersfield Steam Power Plant—In the article describing this installation, on page 476 of the Oct. 6 issue, the fact that the data and photographs were furnished by the J. G. White Engineering Corporation, New York City, was not incorporated. They were also the engineers who constructed the plant.

⁂

The third annual gas-power show of the National Gas Engine Association will be held in Toledo from Oct. 19 to 24. A feature of the program this year will be an engine and food-grinding contest under the direction of the farm power committee. In this connection a series of tests will also be conducted by the American Society of Agricultural Engineers.

POWER

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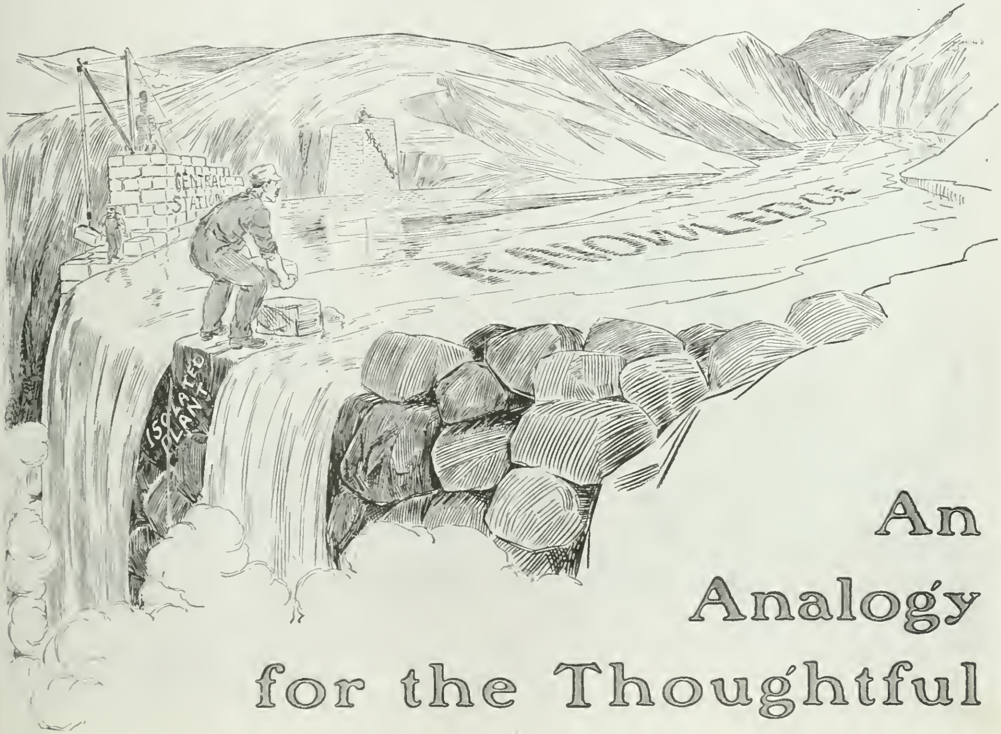

An Analogy for the Thoughtful

IN the Engineering Country there is a River of Knowledge which has its fountain head high up in the Hills of Truth. This river is continually carrying down from the mountains the water from the Springs of Facts. To retain this water and swell the River of Knowledge, the Men of Industry and Study are building the great Dam of Science. Each group must keep its position up to the standard of the rest or be submerged and washed over the brink into the Abyss of Oblivion, while another group of builders or the adjoining ones fill in the place vacated.

The Central Station Builder is now reaching out and crowding the Isolated Plant Fellow, who will have to hustle to hold his place. The Specialist is building not so wide as some others, but higher, and is sufficiently ahead of the rest to be well out of danger. That the standard is being raised is everywhere evident. Science is constantly growing. The model power plant of a few years ago, with its then excellent equipment and commendable performance, is quite ordinary today, and there is as great a contrast in the engineers who operate them. *(Contributed by J. J. Ramsey, Wellington, Kan.)*

Power for Karpen Factory

By Thomas Wilson

SYNOPSIS—Review of installation built up from belt and rope drive to a central plant and electrical distribution. Choosing between a simple and compound engine. Steam is made for 19.6c. per 1000 lb., and in combination with the heating, current, costs 0.81c. per kw.-hr., including fixed and operating charges.

⁂

A maker of upholstered furniture, S. Karpen & Bros., of Chicago, has had an interesting experience in supplying power for the factory. Starting with line shafts in the various buildings, interconnected by rope drives and all turned by one large Corliss engine, this firm, after giving central-station current a year's trial, has finally installed an isolated plant and motors for individual and group driving. The plant was put in operation the first of the year and, as the records presented herewith will show, has been giving good results.

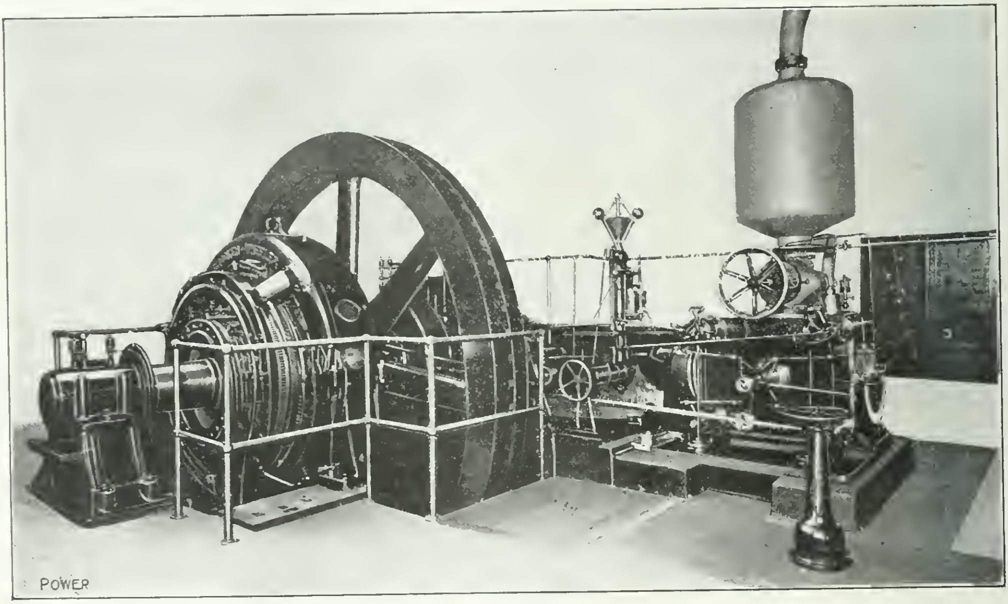

Fig. 1. Simple Corliss, 300-Kw. Unit

It was in May, 1899, that the company moved to its present location at the corner of Twenty-second and Union St. The site contained six acres of ground and at that time there were four three-story brick buildings of mill construction. In 1905, an annex to the mill and a new four-story building were built, bringing the total floor space up to 239,679 sq.ft. The Corliss was already pulling a friction load of 192 hp. out of a total peak load of 450 hp., and as the company did not wish to add to it, motors were placed in the new additions. With no generators in the plant, central-station current was given a tryout. In the annex the load averaged 150 amp. at 230 volts for 85 connected horsepower. In the new building 28 hp. in motors, 100 arc lights and 100 incandescent 16-cp. lamps gave an average demand for 275 amp. Independent meters for the incandescents, arcs and for the power load were put in. At that time, the incandescent lighting was billed at 20c. per kw.-hr., the arcs at 10 to 12c., depending on the demand, and the power load averaged about 4½c. Of course, these rates were exorbitant, and at the end of a year's time two 100-kw. generators were purchased. These units were belt-driven from the main shaft and up to last January have been supplying all electrical energy to the factory.

Boiler Plant

At the same time, a new boiler plant was installed, consisting of four 150-hp. return-tubular boilers, 72-in. by 18-ft., each containing 68 four-inch tubes. The boilers were built for 150-lb. pressure, but 125 lb. is the usual working pressure. The grates are of the shaking and dumping type, measuring 5½x5½ ft. The brick stack is 125 ft. high, 66 in. in diameter at the top and 72 in. at the bottom. Of the fuel used, 25 per cent. is shavings; these are chuted into the furnaces and burned with 6-in. shellbark egg coal. The latter is hand fired and a fuel bed of 6 in. is maintained. Over the fire the draft is 0.24 in. and in the breeching 0.78 in. These are the present conditions as the boiler plant was retained.

Use of Exhaust Steam

For heating the entire plant, there are 25,300 sq.ft. of direct radiation supplied by a two-pipe vacuum system. In the buildings there are eight small drying kilns fitted with 1700 sq.ft. of direct radiation. Outside are seven larger kilns, in which air heated by 8000 sq.ft. of indirect surface is circulated by a fan driven by a 45-hp. motor. For cooking glue there are additional coils, aggregating 3844 sq.ft., which take live steam at 55 lb. pressure. The drying kilns and heating coils in the cabinet-making rooms utilize exhaust steam the year around, and in the four warmer months they take about 70 per cent. of the available supply. This was determined by weighing the condensation. During the balance of the year more or less heating is necessary throughout the entire factory, so that there is demand for all of the exhaust steam, and in the coldest weather some live steam in addition. During the day about 38 per cent. of the steam generated is used directly for manufacturing purposes.

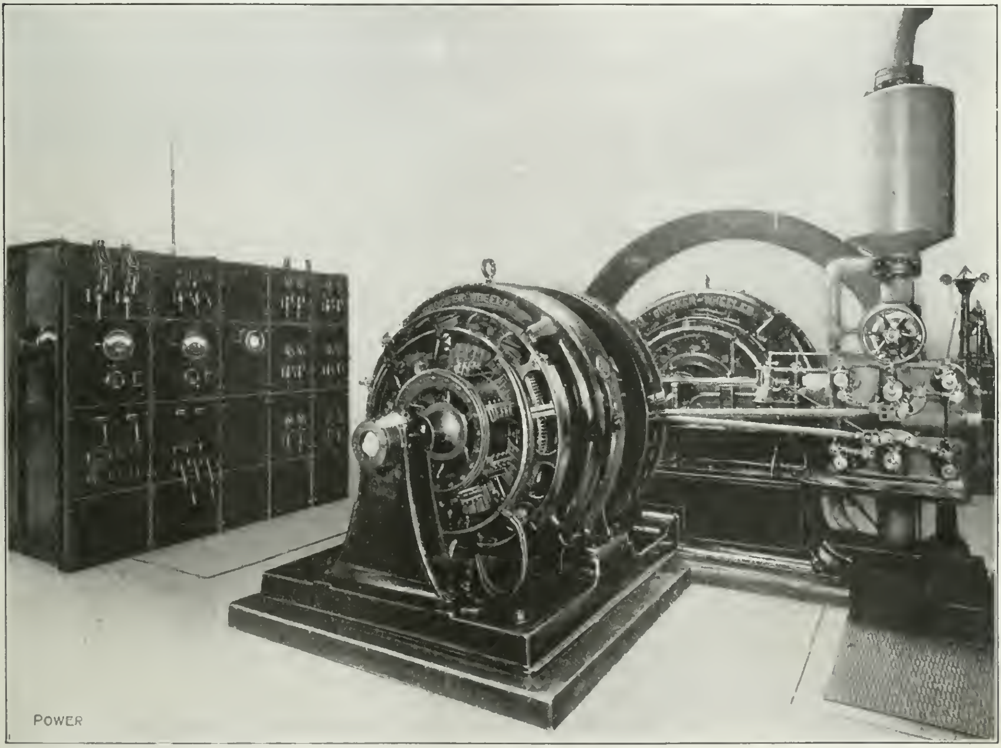

Fig. 2. Four-Valve, 100-Kw. Unit and Switchboard

Install Isolated Plant

As time wore on, the long lines of shafting and the rope drives began to wear out. A change was necessary, and the heavy friction loads of the past induced the company to put in electrical transmissions throughout. The central station again came forward, offering a minimum rate of 1.8c. and a maximum not to exceed 3c. Large demands for exhaust steam so influenced the cost of producing current, however, that a contract on this basis would have meant a large loss. A careful estimate, which has been verified by the records of the past six months, showed that the company could not afford to pay more than 1.3c. per kw.-hr. for its current. It was obvious that an isolated plant would soon pay for itself and in the latter part of 1913 the necessary generating equipment was purchased.

Simple Corliss or Compound Four-Valve?

As soon as a plant had been decided upon, a discussion arose as to the proper type of prime mover. Frank Ory, the engineer, favored a simple Corliss making 100 r.p.m., arguing that although the slow-speed machine would be large for its capacity and costly, its mechanical efficiency would be high and the cost of upkeep a minimum. The engine would use more steam than a compound unit, but for the greater part of the time all of the exhaust steam would be utilized, so that the steam rate was of little consequence. A consulting engineer retained by the company favored a cross-compound four-valve engine, making 150 r.p.m., to obtain advantage of the lower steam rate in the summer months. Mr. Ory carefully analyzed the two cases and showed that his choice would save money in the course of a year, even with a higher steam rate and a cost for the unit $766 greater than that listed for the compound machine. His method of arriving at this conclusion may be of interest.

From his long experience in the plant, he determined that the average day load for the year would be 250 kw. and the peak load for three hours per day and four months per year during the heavy heating season would be 325 kw. He placed the evaporation at 7 lb. of water per pound of coal and estimated that 25 per cent. of the water would be evaporated by shavings and floor sweepings. Thus 75 per cent. of the fuel would be coal costing $3 per ton in the bunker. A steam rate of 24 lb. per i.hp.-hr. was quoted for the simple engine and 20.5 for the compound. For the simple Corliss, efficiencies of 93 per cent. for the engine and 92 per cent. for the generator were taken, and for the compound 88 and 90 per cent., respectively. The lower mechanical efficiencies for the compound unit were due to cheaper construction, two cylinders instead of one and a lighter generator provided with less copper.

Assuming that only coal is burned under the boilers for 10 hr. per day and 300 days per year, the fuel cost for the steam going through the simple engine to supply the heating system besides generating 250 kw. for power, would be

$$\frac{250 \times 10 \times 300 \times 24 \times \$3}{7 \times 2000 \times 0.93 \times 0.92 \times 0.746} = \$6040$$

For the compound engine the cost would be

$$\frac{250 \times 10 \times 300 \times 20.5 \times \$3}{7 \times 2000 \times 0.88 \times 0.90 \times 0.746} = \$5577$$

The peak load is 75 kw. more than the average for three hours per day and four months per year, so that the following amounts should be added:

For the simple engine:

$$\frac{75 \times 4 \times 3 \times \$6040}{250 \times 12 \times 10} = \$181 \qquad \text{(A)}$$

and for the compound engine:

$$\frac{75 \times 4 \times 3 \times \$5577}{250 \times 12 \times 10} = \$167 \qquad \text{(A)}$$

The $6040 and the $5577 are the yearly totals for 250 kw. and exhaust steam for heating. For eight months the charge against the simple engine would be:

$$\$6040 \times \tfrac{8}{12} = \$4027 \qquad \text{(B)}$$

and for the compound engine

$$\$5577 \times \tfrac{8}{12} = \$3718 \qquad \text{(B)}$$

For the four warm months, when 70 per cent. of the exhaust steam is utilized and 30 per cent. lost to atmosphere, the charge for 250 kw. and heating would be:

For the simple engine,

$$\$6040 \times 0.70 \times \tfrac{4}{12} = \$1409 \qquad \text{(C)}$$

For the compound engine,

$$\$5577 \times 0.70 \times \tfrac{4}{12} = \$1301 \qquad \text{(C)}$$

The cost of the 30 per cent. exhaust steam wasted would be:

For the simple engine,

$$\$6040 \times 0.30 \times \tfrac{4}{12} = \$604 \qquad \text{(D)}$$

For the compound engine

$$\$5577 \times 0.30 \times \tfrac{4}{12} = \$558 \qquad \text{(D)}$$

It is evident that the cost for the year equals the sum of A, B, C and D. Omitting D would give the cost when all of the steam is used for heating. For the simple engine this would be

$$\$181 + \$4027 + \$1409 = \$5617$$

and for the compound engine

$$\$167 + \$3718 + \$1301 = \$5186$$

At the working pressure, 140 lb. abs., the heat contents in a pound of steam is 1192.2 B.t.u. In expanding in the engine to a back pressure of 16 lb. abs., 158.1 B.t.u. are transformed into work, the balance, 1034.1 B.t.u., is available for heating. Then the actual cost of coal for power in the simple engine is

$$\frac{158.1}{1192.2} \times \$5617 = \$745 \qquad \text{(E)}$$

and in the compound engine

$$\frac{158.1}{1192.2} \times \$5186 = \$688 \qquad \text{(E)}$$

To these figures should be added the cost of coal for the 30 per cent. of the steam rejected during four months of the year. This would make the total coal cost for power

$$\$604 + \$745 = \$1349$$

for the simple engine and

$$\$558 + \$688 = \$1246$$

for the compound engine. These figures are based upon using coal only for fuel, but 25 per cent. is shavings, so that the cost for coal would be 75 per cent. of the above amounts, or $1011.75 and $944.50, respectively.

For fixed charges, 5 per cent. for interest and 2 per cent. for insurance and taxes were allowed in each case. Due to higher speed, less weight and more bearings, depreciation for the compound was placed at 7 per cent. For the simple engine 5 per cent. was allowed. The cross-compound, being practically two engines, will use more oil, at least $100 worth, and this was charged against it.

Table 1 is a summary of the fixed charges, fuel cost and additional oil, labor and supplies being considered the same in each case, although the cost of supplies for the compound engine should be slightly greater.

TABLE 1. SUMMARY OF FIXED CHARGES AND FUEL COSTS

	Simple Corliss		Compound Four Valve
Cost of Unit........	$11,966.00		$11,200.00
Interest, 5%.........	$598.30	at 5%	$560.00
Ins. and taxes, 2%...	239.32	at 2%	224.00
Depreciation, 5%....	598.30	at 7%	784.00
Fixed charges	$1,435.92		$1,568.00
Cost of fuel.........	1,011.75		944.50
Cost extra oil.......			100.00
Total	$2,447.67		$2,612.50

It is evident that the difference in favor of the simple Corliss is $164.83, and it would have been greater if a higher-grade compound engine costing more money had been selected. The compound would also have required the use of more live steam for heating in the colder

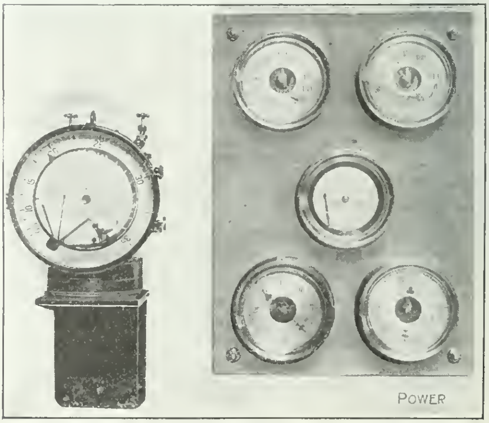

Fig. 3. Flow Meter and Gage Board

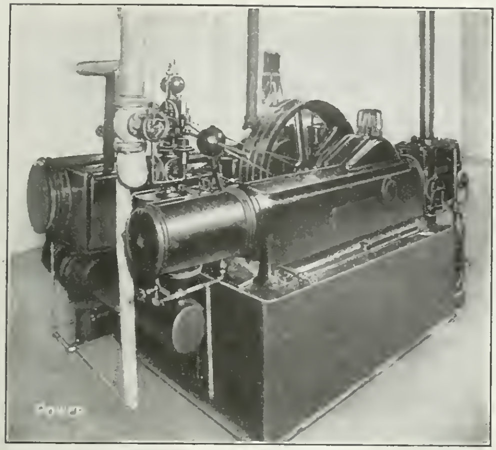

Fig. 4. Compound Steam Two-Stage Air Compressor

weather. Naturally, a simple Corliss engine was set up and put into operation the first of the year.

Engine Room

The main unit to carry the day load consists of a simple full-stroke releasing Corliss engine, 24x36-in. and 100 r.p.m., directly connected to a 300-kw. two-wire generator delivering current at 230 volts, Fig. 1. A 15x17-in. four-valve engine driving a 100-kw. generator at 200 r.p.m handles the night and Sunday loads, Fig. 2. The day load averages about 1100 amp., which at 230 volts would make 253 kw., but the peak load runs as high as 1800 amp., or 411 kw. The large machine easily cares for the overload. At night the average load is not more than 150 amp., so that the small unit is underloaded. Through the day there is plenty of exhaust steam until the temperature gets down to 10 deg. above zero, but at night, with the light load and the heavy demands by the kilns, live steam is required the year around.

A modern switchboard, a water-flow meter, a gage panel, Fig. 3, for live, exhaust steam and air pressures are part of the engine-room equipment. There is also a compound-steam two-stage air compressor supplying air at 80 lb. pressure for factory use. Its capacity is 325 cu. ft. of free air per min. at a speed of 225 r.p.m.

The large engine has a continuous oiling system consisting of a pump driven by the rocker arm of the engine and a small combination separator and filter mounted in a concrete container and attached to the engine base below the floor. As the oil returns from the various bearings it enters the separator, passes through the filter and is pumped to a storage tank mounted on the wall of the engine room. From here it flows by gravity to points of supply. Force-feed pumps lubricate the cylinders of both engines.

Small Live-Steam Piping

A feature of interest is the small steam piping to the engines and large receiver-type separators having volumes four times greater than the engine cylinders. The drop in pressure between boiler and cylinder at full load is only 4 lb. For the large engine a 5-in. pipe rises from a 12-in. header a distance of 3 ft., runs horizontally 20 ft. and drops 5 ft. into the top of the receiver. The steam passes through an 8-in. throttle valve into the cylinder. The exhaust pipe is 9 in. in diameter to the first elbow, then 10 in. to a 14-in. main supplying the heating system or discharging to atmosphere through a 12-in. riser. For the small unit the supply pipe is 3 in. in diameter, the throttle valve 5 in. and the exhaust pipe 6 in. The supply pipe to the large engine has 0.0667 sq.in. of area per kilowatt of rating and the exhaust pipe 0.2093 sq.in. For the 100-kw. unit the pipe areas per kilowatt of rating are 0.0739 and 0.2889 sq.in., respectively.

The large engine is rated at 500 hp. and the small one at 150 hp., the steam rates at full load being 24 and 28 lb. per i.hp.-hr., respectively, or 26.6 and 31.1 per b.hp.-hr. The former would then require at full load

$$\frac{500 \times 26.6}{60} = 221.7 \textit{ lb.}$$

of steam per minute, and the small engine

$$\frac{150 \times 31.1}{60} = 77.7 \textit{ lb. per min.}$$

At an average pressure of 123 lb. gage, the volume of each pound of steam would be 3.27 cu.ft. The volumes of steam per minute passing in each case would be

$$221.7 \times 3.27 = 725 \textit{ cu. ft.}$$
$$77.7 \times 3.27 = 254 \textit{ cu. ft.}$$

Assuming continuous flow, as is usual, the velocity in the supply pipe of the 500-hp. engine would be 5220 ft. per min., and at atmospheric pressure the exhaust velocity would be about 11,600 ft. per min. For the small engine the velocities would be 4950 ft. per min. for the supply and 8820 ft. per min. for the exhaust. The small drop in pressure shows that the pipes are ample, and the good results may be attributed to the large separators.

Operating Records

Table 2 gives the costs of operating the plant for the first six months as computed by the engineer. It will be noticed that steam, whether live or exhaust, for pur-

TABLE 2. COST OF OPERATING POWER PLANT FROM JAN. 1 TO JULY 1, 1914

BOILER ROOM		
Coal, 4,022,363 lb., at $2.60 per short ton	$5,229.07	
Labor, 3 firemen	1,000.00	
Ash removal	130.20	
Heating boiler water, 160° to 212°	853.84	
Water, washing out boilers, etc.	40.00	
Lighting boiler room	25.00	
Blowing down boilers	50.64	
Fixed charges on $6000, int. 5%, dep. 5%, ins. ½ of 1%	315.00	
Total boiler room costs		$7,643.75
Water evaporated, lb.	40,614,458	
Cost evap. 1000 lb. of water, c.	19.6	
Water evap. per lb. of coal, lb.	10.09*	
ENGINE ROOM		
Labor, 2 engineers and one-half chief's time	$1,850.08	
Oils	112.64	
Supplies	218.39	
Water for eng. room, toilet and shower,	35.00	
Light for engine room	25.93	
Steam rejected to atmosphere	178.41	
Fixed charges, 10½% on $17,000	892.50	
Total engine room costs		$3,342.98
Engine and boiler room costs		$10,986.73
CREDITS		
Steam for fire pump at 20c. per 1000 lb.	$199.12	
Steam for heating and manufacturing at 20c. per 1000 lb.	7,088.56	
Steam for compressed air at 20c. per 1000 lb.	573.14	
Total		$7,861.12
Cost of generating electricity		$3,125.61
Kw.-hr. generated		386,100
Cost per kw.-hr., c.		0.81

*Includes water evaporated by shavings, actual evaporation by coal 0.75 × 10.09 = 7.57.

PRINCIPAL EQUIPMENT OF S. KARPEN & BROS. FACTORY PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Return tubular	72-in. x 18 ft	Generate steam	Natural draft, 125 lb. gage	Frost Mfg. Co.
4	Grates	Dumping and shaking	5½x5½ ft.	Boiler furnace		Economic Engineering Co.
2	Pumps	Simplex	10x6x12-in. and 12x7½x12 in.	Boiler feed water	125 lb. steam pressure	American Steam Pump Co.
2	Pumps	Simplex	6x8x12-in. and 8x10x12-in.	Vacuum heating system	125 lb. steam pressure	American Steam Pump Co.
1	Heater	Open	1000 hp.	Heat feed water	Exhaust steam	Warren Webster & Co.
1	Fire pump	Duplex	18x10x12-in.	Fire protection	1000 gal. per min. at 70 strokes	Fairbanks Morse & Co.
1	Meter	Water flow		Recording boiler feed		General Electric Co.
1	Engine	Simple Corliss	24x36-in.	Main unit	125 lb. steam, atm. exh., 100 r.p.m.	Nordberg Mfg. Co.
1	Generator	Direct current	300 kw.	Direct connected to Corliss	230 volt, 100 r.p.m.	Crocker-Wheeler Co.
1	Engine	Four valve	15x17	Main unit	125 lb. steam, atm. exh., 200 r.p.m.	Chuse Engine & Mfg. Co.
1	Generator	Direct-current	100 kw.	Direct connected to four-valve	230 volt, 200 r.p.m.	Crocker-Wheeler Co.
1	Air compressor	Compound steam Two-stage air	8x13x12-in 7½x12x12-in.	Air at 80 lb. to factory	125 lb. steam, 225 r.p.m.	Ingersoll Rand Co.
4	Gages	Indicating	10-in. diam.	Steam and vacuum		Bogardus Co.
1	Gage	Recording	10-in. diam.	Boiler pressure		Bogardus Co.
2	Ammeters		One 2000 and one 600 amp.	Generator current		Weston Electrical Instrument Co.
1	Voltmeter	Swinging bracket	600-volt.	Generator voltage		Weston Electrical Instrument Co.
1	Watt-hour meter	Recording		Record output		Sangamo Electric Co.

poses other than generating electricity are properly credited at the cost of production. Much of the steam credited to heating has already passed through the engines, but without the engines live steam would be needed to take its place, so the credit is legitimate. The same plan is followed out in charging the exhaust steam used for heating the feed water and that wasted to atmosphere. This procedure is unusual, but consistent with the heating charge. The item for blowing down boilers would seem to be already covered by previous charges, but it is so small that results will not be influenced much either way.

A cost per 1000 lb. of steam of 19.6c. is fair for a hand-fired plant, and a cost of 0.81c. per kw.-hr., including both operating and fixed charges, is excellent—in fact, much less than the central stations' cost of production. If current had been purchased, the services of one engineer only, amounting to $480 for the six months, could have been dispensed with. The fixed charge item on the generating equipment, most of the oil and supply items and the rejected steam charge would also be eliminated. This makes a total of

$$\$480 + \$892.50 + \$178.44 + \$248.39 + \$112.64 = \$1911.97$$

Dividing by 386,100 kw.-hr., gives 0.49c. Adding this to the 0.81c. makes a total of 1.3c. per kw.-hr., the maximum the company could afford to pay for central-station service. When this is compared to a minimum rate of 1.8c. increased to approximately 3c. by the numerous charges usually annexed, it is plain that an isolated plant in this case is paying big dividends.

Boring Engine Cylinders

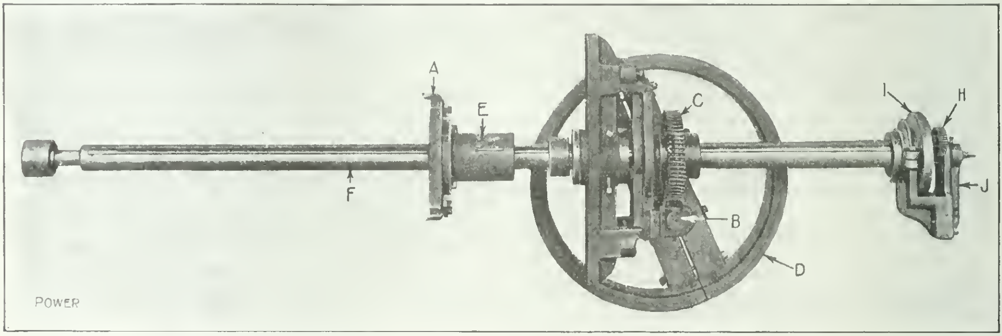

FIG. 1. BORING BAR, SHOWING DRIVING MECHANISM

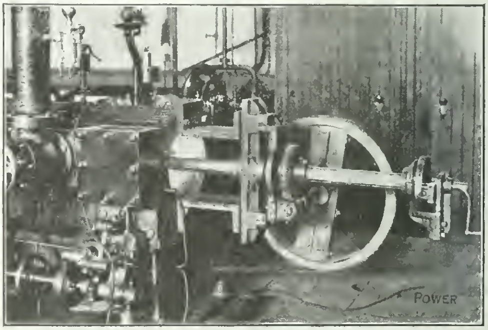

FIG. 2. BAR IN POSITION IN ENGINE CYLINDER

The accompanying photographs illustrate a boring bar designed for convenient use in the power plant. It may be used for boring engine cylinders, Corliss engine valve ports, crosshead slides, bearings that have been rebabbitted, etc. Fig. 1 shows the bar complete except for the crank-end bearing frame which, although furnished with each bar, is not ordinarily employed when boring an engine cylinder, because this bearing is fixed in the piston-rod stuffing-box. The cutter head *A* is shaped like a four-point star. Three of the arms carry the regular cutting tools while the fourth is designed to hold a tool at 45 deg. so that the point is in advance of the face of the cutterhead when making the cylinder counter bore, The bar is revolved by the worm *B* and wheel *C* driven from any power source through the pulley *D*. The worm and wheel are used to produce a steady motion, free from chattering, and to insure a smooth clean cut. The cutter-head carrier *E* is fitted with two lugs or keys which slide in races cut in the side of the bar. Thus, while the carrier may slide freely along the bar, it must revolve with it.

The carrier is fed backward or forward by means of the long screw *F* turning in a slot in the side of the bar and meshing with a half-nut fixed on the inside or bearing surface of the carrier. The feed screw is made to revolve automatically by means of a train of gears, the ratios of which can be changed to produce any rate of feed from $^1/_{64}$ to $\frac{1}{4}$ in. per revolution of the boring bar.

At the right of the photograph the large gear *H* is fixed to the disk *I* which is integral with the bar. Thus the gear moves in a circle when the bar revolves. It meshes with a gear secured to the frame *J* which hangs on a loose collar on the end of the bar and, hence, does not revolve with the bar. Another gear on the same pin as gear *H* drives a gear fixed on the end of the feed screw.

For protection and adjustment at each bearing, the bar is fitted with a movable sleeve which takes all the wear. This sleeve and the bearing are slightly tapered so that the wear can be taken up by shifting the sleeve.

The bar is made by Boxill & Bruel, 848 West Sixth St., Cincinnati, Ohio, in two standard sizes for cylinders from 4 to 16 in. and from 16 in. to 60 in. The standard lengths are 6 and 12 ft., but special sizes can be furnished. When a plant is not large enough to warrant the purchase of a bar, the manufacturer will lease one for any desired length of time.

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The Effect of Compression

By Robert C. H. Heck

SYNOPSIS—A digest of several sets of experiments upon the effect of compression on steam-engine economy, with conclusions that a small amount of compression is desirable, but should not increase with earlier cutoff: also, that wasteful effect of excessive compression is greater with light load than with full load. The tests seem unanimous in recommending about two units of compression for noncondensing engines, and rather more for condensing engines. All the data referred to indicate that clearance steam is by no means free from moisture at the beginning of compression.

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Following the pioneer work of Dwelshauvers-Dery and the Duchesnes at Liège, several sets of careful and extensive experiments upon the effect of compression on the economy of the steam engine have been made in different European college laboratories. The recent publication of the last of these, in January of the current year, makes this an appropriate time for presenting a digest of them all. Introductory particulars of the tests to be reviewed are as follows:

A. By Prof. Dwelshauvers-Dery, at the University of Liège, published in *Revue de Mécanique,* 1897, Vol. 1, page 939; see also Power, June 28, 1910, page 1157. Four-valve engine, cylinder 300x600 mm. (11.8x23.6 in.), clearance 0.066. Engine run noncondensing, with steam of about 80 lb., absolute pressure, superheated 80 deg. F.; steam jackets not in action; speed varied.

B. By Dr. H. Klemperer, at the Dresden Technical High School, in 1903; published in *Zeitschrift des Vereines deutscher Ingenieure,* May 20, 1905, pages 797-807. Corliss engine, steam-jacketed on barrel and heads, cylinder 180x450 mm. (7.1x17.7 in.), extended piston rod 1.57 in. diameter on both sides of piston, clearance 0.045, speed 102 r.p.m. Engine run condensing with steam of 100 lb. absolute pressure, noncondensing with 114 lb. absolute.

C. By Prof. J. Boulvin, at the University of Ghent, published in *Revue de Mécanique,* 1907, Vol. 20, pages 109-136. Corliss engine, valves in cylinder heads, full steam jackets; cylinder 250x500 mm. (9.8x19.7 in.); clearance 0.038, speed 102 r.p.m.; run noncondensing with saturated steam of about 92 lb. absolute pressure.

D. By E. Heinrich, at the Stuttgart Technical High School, published in *Zeit. Ver. deutsch. Ing.,* Jan. 3, 1914, pages 15-22 and Jan. 10, 1914, pages 58-62. Lift-valve engine, full steam jackets, cylinder 250x760 mm. (9.8x30 in.), clearance 0.087; r.p.m., 92.5; engine run condensing with saturated steam of 116 lb. absolute, and with an absolute pressure of about 2.2 lb. below the exhaust valves.

Each experimenter has gone into a more or less elaborate thermodynamic analysis of his observations and results. The present purpose, however, is to consider no more than the principal, primary determination of steam consumed per indicated horsepower-hour. But before giving and comparing the results of experiment, a simple rational deduction will be worked out, based on three good average empirical assumptions; and it will be found that the conclusions derived from this preliminary discussion will agree very well in form with the experimental curves. The three assumptions to be made are:

(*a*) That equilateral hyperbolas well enough represent the average form of actual expansion and compression curves.

(*b*) That the clearance steam may be taken as dry saturated at the beginning of compression.

(*c*) That for a given cylinder, engine speed, and pair of limiting pressures, the missing steam at cutoff will be constant in amount, or independent of cutoff and compression.

From each of these, actual performance may depart pretty widely; but in general, the departures are quantities of the second order of magnitude, whose study belongs to a close and detailed analysis.

Theoretical Deduction

In Fig. 1, outline *ABCDEFA* is a steam or indicator diagram which is ideal in that it shows none of the losses of pressure and the rounding of corners due to pipe, port and valve action. But the steam is supposed to be under the full thermal influence of the cylinder wall, so that the amount present at cutoff and actually filling the space *PB* would have the volume *PG* if none of it were condensed. Under assumption *(a)*, curves *BC* and *EF* are of the form $pv = C$.

Now, the whole weight of steam substance present at cutoff and during expansion is made up of two parts, the clearance steam caught and compressed from the preceding cycle and the new steam supplied from the boiler for the present cycle. If the former is known, its full, dry volume can be laid off as *PH*, and its volume as a portion of the actual steam-and-water mixture at cutoff will be *PJ*. In this particular diagram, *PB* is 0.7 of *PG*, hence also *PJ* is 0.7 of *PH*. The initially condensed or "missing" steam, which would be represented by volume *GB*, is then 30 per cent. of the total steam. As cutoff and compression vary (see Fig. 2), this quantity *BG* is to remain constant, not relatively or as a percentage, but absolutely.

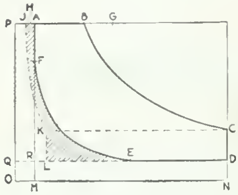


FIG. 1

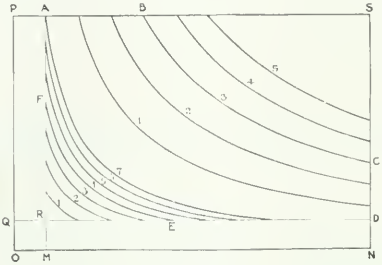


FIG. 2

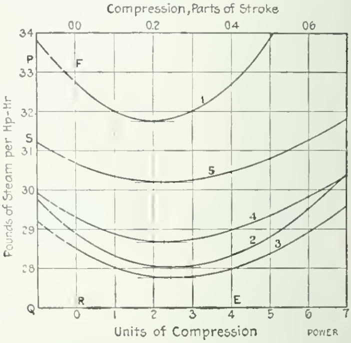


FIG. 3

Fig. 1. Ideal steam diagram, with separate steam expansion curve for the clearance steam. Fig. 2. Group of ideal diagrams, with varying cutoff and compression. Fig. 3. Curves showing variation of steam consumption with compression.

If the whole steam measured by volume *PG*, Fig. 1, were admitted to a cylinder without any clearance space at all, while yet suffering the shrinkage *GB* because of wall action, it would perform the work represented by area *PBCDQP*. By drawing an equilateral hyperbola *JK*, like *BC* and ending at the same terminal pressure, the whole work area is divided into proportional parts, *PJKLQP* for the weight of clearance steam and *JBCDLKJ* for the weight of fresh steam.

In the actual engine, with piston displacement beginning at *MA* instead of *OP*, the net work to be credited to the supplied steam is area *ABCDEFA*. Then the shaded area between *EFA* and *JKL* represents the loss of possible work output due to clearance and compression.

The measurement of steam consumed in a given time, from which can easily be computed the steam supplied to the cylinder per cycle, is one of the main determinations in an engine test. The weight of clearance steam cannot be measured, but must be inferred from the indicator diagram, by methods which at best have in them some degree of uncertainty. Assuming dry saturation at *E*, its weight is found from volume *QE* and pressure *OQ*.

Whatever the actual behavior of the clearance steam during compression, and whether or not curves *BC* and *EF* are really of the same form, the average quality or degree of dryness is higher during compression than during expansion. Therefore, when a separate expansion curve *JK* is drawn for the weight of clearance steam, it will lie within or to the left of curve *FE*. The earlier assumption that a curve like *JK* will agree with *FE*, or that in expansion the clearance steam will give back all the work expended in compressing it, is erroneous and leads to false conclusions.

GROUP OF IDEAL DIAGRAMS

In Fig. 2 is shown a combination of 40 diagrams like Fig. 1. The five expansion curves are marked by numbers which indicate cutoff in tenths of the stroke. The numbers on the compression curves similarly show compression *ER* in tenths of stroke *NM*. Including zero, there are eight compressions to be combined with each of the five cutoffs.

Now any area *ABCDEFA* represents work done. From a volume got by adding a constant *BG* (Fig. 1) to the variable *PB* can be computed the weight of total steam, and from volume *QE* the weight of clearance steam. It is then not difficult to calculate steam consumption *S* in pounds per horsepower-hour, and most simply by letting stroke *MN* represent a piston displacement of 1 cu.ft. The results of this calculation are laid out in Fig. 3, where each curve is for a particular cutoff and a horizontal tangent determines the best compression (giving lowest steam consumption) with each cutoff.

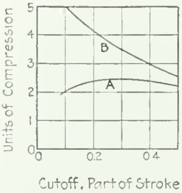


FIG. 4. CURVES OF BEST COMPRESSION

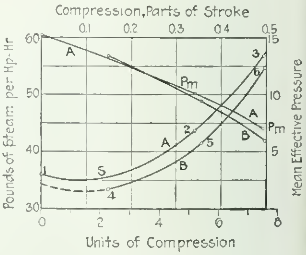


FIG. 5. DWELSHAUVERS-DERY STEAM-RATE RESULTS

VARIATION OF STEAM CONSUMPTION WITH COMPRESSION

The curves, Fig. 3, really begin at end line *RF* (Fig. 2) for zero compression; but the dotted extensions show what would be the effect of a complete emptying of the clearance space; if this were possible, it would make *PG*

(Fig. 1) the required amount of fresh steam. The unit of the scale at the bottom of Fig. 3 is the clearance volume. Because clearance was taken as 10 per cent. in Fig. 2, "units of compression" here agree with tenths of stroke; but generally the two scales are different, as appears in Figs. 5, 7, etc.

Curves of Best Compression

A very important showing of Fig. 3 is that the best compression is not large, ranging from 2 to 2.5 units for the determining conditions of these diagrams, and that it varies but little with the amount of expansion. The plot of best compressions in Fig. 4, on cutoff as base, brings this out even more clearly. Curve *A* is from Fig. 3, while curve *B* is got from Fig. 2 and a group of curves like Fig. 2, but based on the assumption that expansion *JK* in Fig. 1 will coincide with compression curve *EF*. Subject to secondary influences which will modify it in detail without changing its essential form, curve *A* (Fig. 4) represents actual engine working and shows that, instead of continually increasing as cutoff becomes earlier, the most advantageous compression is nearly constant over a wide range and grows less for very early cutoff, and from Fig. 3 it appears that the harm done by wrong compression is relatively greater with early than with late cutoff.

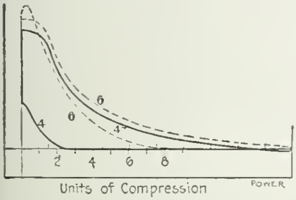


Fig. 6. Indicator Diagrams, Tests Nos. 4 and 6 of Fig. 5.

Review of Experiment

All the experiments to be presented were made in the metric system, but have been reduced to English units.

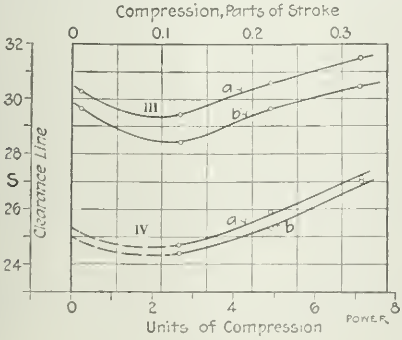


Fig. 7

Klemperer's steam rates: Noncondensing, no steam in jackets, 111 lb. absolute steam pressure, Series III, saturated steam, Series IV, steam superheated about 90 deg. F., groups a, cutoff 0.20, groups b, cutoff 0.30.

The two important relations between units are that 1 kg. per sq.cm. — 14.22 lb. per sq.in., and that 1 kg. per metric hp. = 2.235 lb. per English hp.

Dwelshauvers-Dery Tests

The six tests reported by Prof. Dwelshauvers-Dery are represented by Figs. 5 and 6. The principal curves in Fig. 5 show steam rate *S*, while the m.e.p. or p_m is also given, chiefly to emphasize the lightness of the load on the engine. Cutoff was made so early (at 0.1 of the stroke) because full expansion to exhaust pressure was desired: the engine would have a better steam rate with fuller admission. The tests are in two groups, Nos. 1 to 3 made at 45 r.p.m., and Nos. 4 to 6 at 62 r.p.m.

In laying out the curves of Fig. 5, the writer has not followed those of the experimenters in their published report. They give the amounts of compression as zero for No. 1, 0.1 for No. 4, 0.3 for Nos. 2 and 5, and 0.4 for Nos. 3 and 6. But the indicator diagrams do not show these nominal values to have been realized; in Fig. 6, for instance, the actual compression is about 0.15 for No. 4 and nearly 0.5 for No. 6. The original curves of steam rate *S* dropped continually from high compression toward zero compression, seeming to show that any least degree of compression was harmful. The curves here drawn, with a minimum of steam rate at about 1.5 units of compression, better represent the experiments and are in accord with the other results, and with reason.

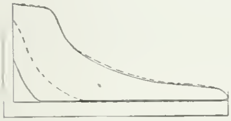


Fig. 8

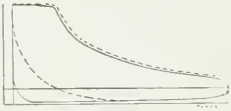


Fig. 10.

Fig. 8. Indicator diagrams line IIIa in Fig. 7; cutoff, 0.20; compression, 0.12 and 0.32. Fig. 10. Indicator diagrams, line Ia in Fig. 9; cutoff, 0.23; compression, 0.085 and 0.50.

Klemperer Steam Rates: Noncondensing

The principal groups of Klemperer tests are given in Figs. 7 and 9, with atmospheric exhaust and with vacuum, respectively; there is a further differentiation between saturated and superheated steam in Fig 7 and between the use and nonuse of steam jackets in Fig. 9.

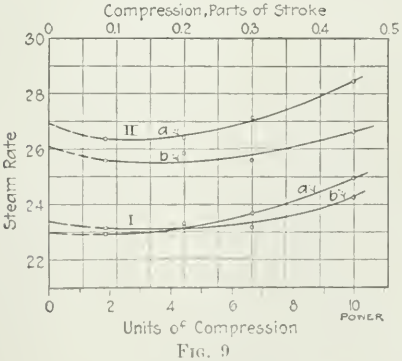


Fig. 9

Klemperer condensing tests: Saturated steam at 100 lb. absolute pressure; Series I, steam in jackets, Series II, no steam in jackets; exhaust pressure, 2.6 lb. absolute; groups a cutoff 0.12; groups b, cutoff 0.23.

With steam jackets in action, the steam used in them is included in the steam rate *S*. The earlier cutoff is short of that for best economy in both sets of tests, as is shown by curve *a* lying from 2 to 3 lb. above curve *b* at III and II; but the tendency of both economy-promoting expedients—that is, of superheating and of steam jacketing—to neutralize the bad effects of too early cutoff is shown by the approach of curve *a* to curve *b* at IV and I.

The curves of Fig. 7 are like those of Fig. 3 in having their minima at about two units of compression. As is reasonable, the best compression when running condensing (Fig. 9) is greater, ranging from 3 to 4 units. Dr. Klemperer ran some other tests which it is not worth while to reproduce here. In one case, the cutoff was made so early as to give complete expansion, and the curve of steam rate is of the same form as those drawn in Fig. 6. In another series, the clearance volume was increased, by setting out the cylinder heads, from 4.5 to 14.5 per cent.: this considerably increased the best amount of compression, when measured in parts of the stroke, but made it less in terms of multiples of the clearance volume.

BOULVIN TESTS WITH STEAM JACKETS

The tests by Prof. Boulvin, Figs. 11 and 12, are in groups with compression kept constant and cutoff varied; then the primary curves, Fig. 11, are each for a particular value of compression, expressed and marked in per cent. of stroke. Having these, it is a simple matter to take intersections of the curves with a line of uniform cutoff and project them over, as from *A* to *B*, upon ordinates located by degrees of compression. This gives the curves in Fig. 12, similar in terms to Figs. 3, 5, 7 and 9, and designated by cutoff values in per cent of stroke

Two anomalies appear in this group of tests. The first is the inconsistent shape of the curve for 3 per cent. of compression in Fig. 11: from the way that it cuts across the other curves, at such a decidedly different slope, results the peculiar shape of the curves in Fig. 12 at their left-hand ends. However, since there are but three experimental points to determine primary curve 3, it may be considered an erratic variation. Another peculiar point is the marked reversal of curvature to the right of the minima in Fig. 12. A trace of the same tendency appears in curves III of Fig. 7, but further experimental evidence would be needed to establish such a shape of curve as typical or characteristic.

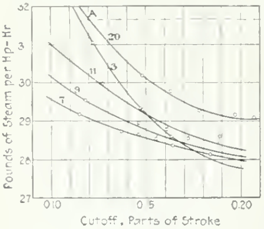


FIG. 11

Boulvin tests, plotted as made with compression held constant and cutoff varied.

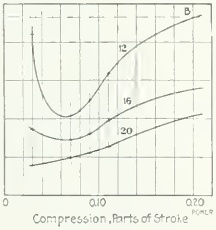


FIG. 12

Curves derived from Fig 11 with compression varying under constant cutoff.

Steam pressure, 92 lb. absolute; r.p.m., 102; clearance, 0.038; steam jackets in action and jacket steam included in steam consumption; exhaust at pressure of atmosphere.

BOULVIN TESTS WITHOUT STEAM JACKETING

A second group of Boulvin tests, made without steam in the jackets, is represented by Figs. 13 and 14, which are similar in scheme and relation to Figs. 11 and 12. Having only three determining points, there is much freedom as to the shape of the derived curves in Fig. 14, and they are made consistent with Fig. 3 in shape, rather than with Fig. 12. Clearance being 3.8 per cent., the minima of steam consumption lie at about two units of compression in both Fig. 11 and Fig. 13.

HEINRICH TESTS

The Heinrich tests, directly diagrammed in Fig. 15, were run with different compressions under constant cutoff. A special variable was the amount of clearance surface, which was changed by fastening to the cylinder heads perforated cast-iron plates, separated by thin distance blocks. The engine has the very unusual feature of a crank of variable throw, such as is commonly used in certain machine tools. In these experiments, the stroke was shortened from the full 30 in. to as little as 27.6 in., being adjusted so as to keep the clearance-volume ratio the same for each amount of artificial surface. As noted beneath the diagram, the open-circle points and full-line curves show tests made with steam jackets, the upper group of points and curves tests without jackets. Within these groups, the varying condition was amount of surface, which was about as follows:

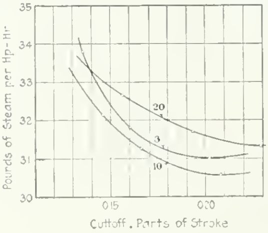


FIG. 13

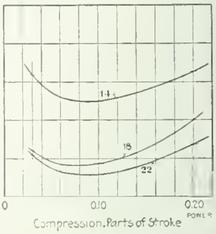


FIG. 14

Fig. 13. Boulvin tests without steam jacketing, other conditions as in Fig. 11. Fig. 14. Curves derived from Fig. 13 with compression varying under constant cutoff.

Curves	Clearance Surface
1 and 6	4.82 sq.ft.
2 and 7	6.11 sq.ft.
3 and 8	7.61 sq.ft.
5, 5 and 9	8.96 sq.ft.

Curves 4 and 5 are for the same arrangement of surface, but differ because the exhaust pressure was 2.12 lb. for No. 4 and 2.79 lb. for No. 5.

The main points of interest in the present connection may be summed up in two brief statements concerning Fig. 15, namely:

Along with the smaller steam rate, when the jackets are in action, goes the fact that the curves are flatter, showing that the harmful influence of excessive compression is less as the conditions within the cylinder are better.

The influence of compression is small in this condensing engine, but there is a well established minimum of steam rate at about 2 units of compression without jackets and at nearly 3 units with jackets.

CONCLUSIONS

The experimental curves of steam consumption, with compression as base, are generally similar to those laid out in Fig. 3. They confirm the deduction that a small amount of compression is desirable for steam economy: but this should not increase with earlier cutoff, and the wasteful effect of excessive compression is greater with light load than with full load on the engine.

For noncondensing engines, the experiments are remarkably unanimous in recommending about two units of compression, or enough to raise the terminal pressure (at end of compression) to 30 or 40 lb. above atmosphere. For condensing engines, the best length of compression is greater, but the resulting pressure rise will be smaller.

These experiments are all made with comparatively small engines, in which the action of the cylinder walls upon the steam is relatively greater than in large cylinders. They show that as the expedients for weakening wall action (superheating and jacketing) are more effective, the influence of varying compression upon steam consumption is weaker: and increase of size will have a similar effect.

Combining the indications of experiment with the reasoning under Fig. 1, it can be seen that if working conditions are such as greatly to diminish or even to abolish initial condensation, the average quality of the total steam during expansion may be as high as the average quality of the clearance steam during compression. With high superheat, for instance, say of 200 to 300 deg. F., the steam in the cylinder at cutoff will not have been cooled all the way down to saturation temperature because of its surrender of heat to the cylinder walls.

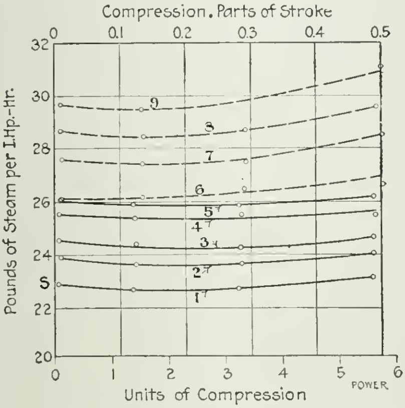


FIG. 15.

Heinrich tests, saturated steam of 116 lb. absolute pressure, cutoff kept constant at 0.18 of stroke; engine run condensing, exhaust-pipe pressure, 2.1 to 2.5 lb. absolute; clearance, 0.087; clearance surface varied; speed, 92.5 r.p.m. Curves 1 to 5, full steam jackets; curves 6 to 9, no steam jackets.

These considerations show that there is nothing unreasonable or contradictory to the data here set forth, in the very high economy given by the Stumpf "uniflow" engine, which of necessity has large clearance and full compression, nearly or quite up to admission pressure. With every care taken to diminish or prevent initial condensation, the expanding steam may have as high quality as the compressed steam. This would make a partial expansion curve such as *JK* in Fig. 1 practically run back along *FE*, thus greatly diminishing the shaded area which represents loss, and making the curve of best compression approch form *B* in Fig. 4. Under conditions of this sort, it is possible for compression to neutralize in very large degree the bad influence of clearance.

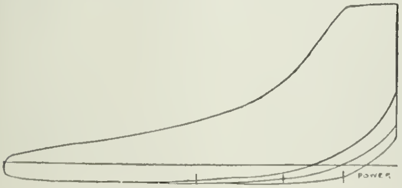


FIG. 16. INDICATOR DIAGRAMS WITH CURVE NO. 6, FIG. 15

On the question of steam quality during compression—a matter which is discussed by everyone of the experimenters quoted—it is enough to say that all the data indicate that the clearance steam is by no means free from moisture at the beginning of compression, but may have a dryness fraction running as low as 0.7 to 0.5. Since superheating will exert a more direct and relatively greater effect on expansion than on compression, this helps to support the hypothesis of practically equal average steam quality for the two curves in certain high-grade engines.

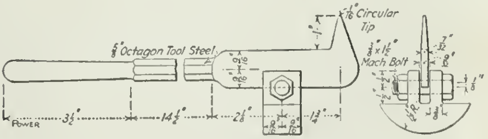
⁂

Tool for Detecting Weak Boiler Tubes

BY C. A. CRAN

Engineers using Illinois coals under water-tube boilers are confronted with the problem of tube corrosion close to the tube sheets or headers, caused by the accumulation of soot and fine ashes. Our boilers are of the Heine type and are fitted with a steam soot-blower installation. This keeps the larger part of the tube surface in good condition, but it does not prevent the collection of soot and ash on the tubes for a space of about four inches just inside the tube sheet. When a boiler is shut down and cooled off, this deposit becomes damp, and the tube in contact with it corrodes away so thin at the ends as to require removal, while the balance is good for much longer service. Our chemist has shaken this soot up with water and found the water acid to litmus paper and giving tests for sulphuric acid, evidently derived from the high sulphur content of the coal used.

The writer designed the tool shown to detect tubes weakened by corrosion. To use it, the curved piece is placed just inside the end of the tube and the lever on it, with the sharp point against the tube surface to be tested. A pull of about 75 lb. will pierce a tube when corroded to $^3/_{64}$ in. thickness, but a tube over $\frac{1}{16}$ in. thick will give a springy or yielding feel when force is exerted on the tool so that weakness is shown before the tube is on the point of failure. The tool will make no impression on a new No. 11-gage tube. The dimensions shown are for 3½-in. tubes, but may readily be altered to suit tubes of other sizes, and the diameter of the tip may be varied to suit the ideas of the user. The lever and fulcrum are not permanently bolted together, as it is frequently easier to insert them separately.



TOOL FOR DETECTING WEAK BOILER TUBES

Condenser and Heater Calculations

By Frank R. Wheeler

SYNOPSIS—Charts for readily finding the square feet of cooling surface required in a surface condenser, the amount of cooling water required, and the amount of heating surface for a heater. The derivation and use of the charts are explained.

All problems involving the transfer of heat from one body to another contain a factor called "temperature head" or pressure. In surface condenser and closed feed-water heater calculations, this temperature head is the difference between the steam temperature and a mean temperature of the water circulating through the tubes. The arithmetic mean is often used, but in these calculations, where the temperature of the out-going water so nearly approaches the steam temperature, a more accurate value is necessary. The following formula, generally attributed to Grashof, and also derived by C. P. Poole

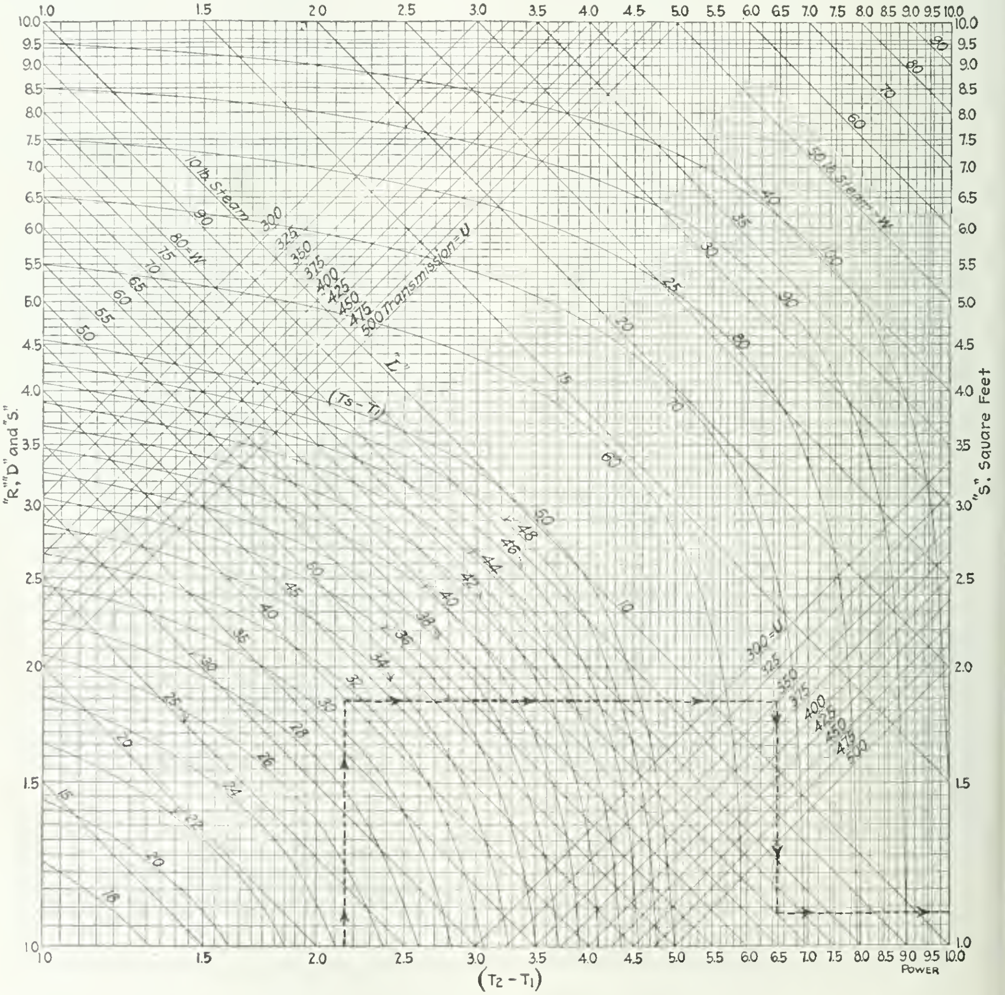


Fig. 1. Chart for Surface Condensers

$$S = \frac{W\,L}{U\left(\dfrac{T_2 - T_1}{\log_e \dfrac{T_S - T_1}{T_S - T_2}}\right)}$$

$$R = \frac{L}{(T_2 - T_1)}$$

where S = square feet of tube surface; W = pounds of steam per hour; L = latent heat, asumed as 1000; U = B.t.u. transmitted per square foot per hour per degree difference of temperature, T_S = temperature of vacuum; T_2 = outlet temperature of water; T_1 = inlet temperature of water; R = ratio of condensing water to condensed steam.

(POWER, Vol. 26, p. 738), as well as Hausbrand and Lucke, is as follows:

$$D = \frac{T_2 - T_1}{\log_e \dfrac{T_s - T_1}{T_s - T_2}}$$

Let S = Square feet of tube surface;

T_s = Temperature of steam;

T_2 = Temperature of water leaving tubes;

T_1 = Temperature of water entering tubes.

SURFACE CONDENSERS

A surface condenser is an appliance to effect a transfer of heat from steam to circulating water and its heat balance may be expressed by the formula:

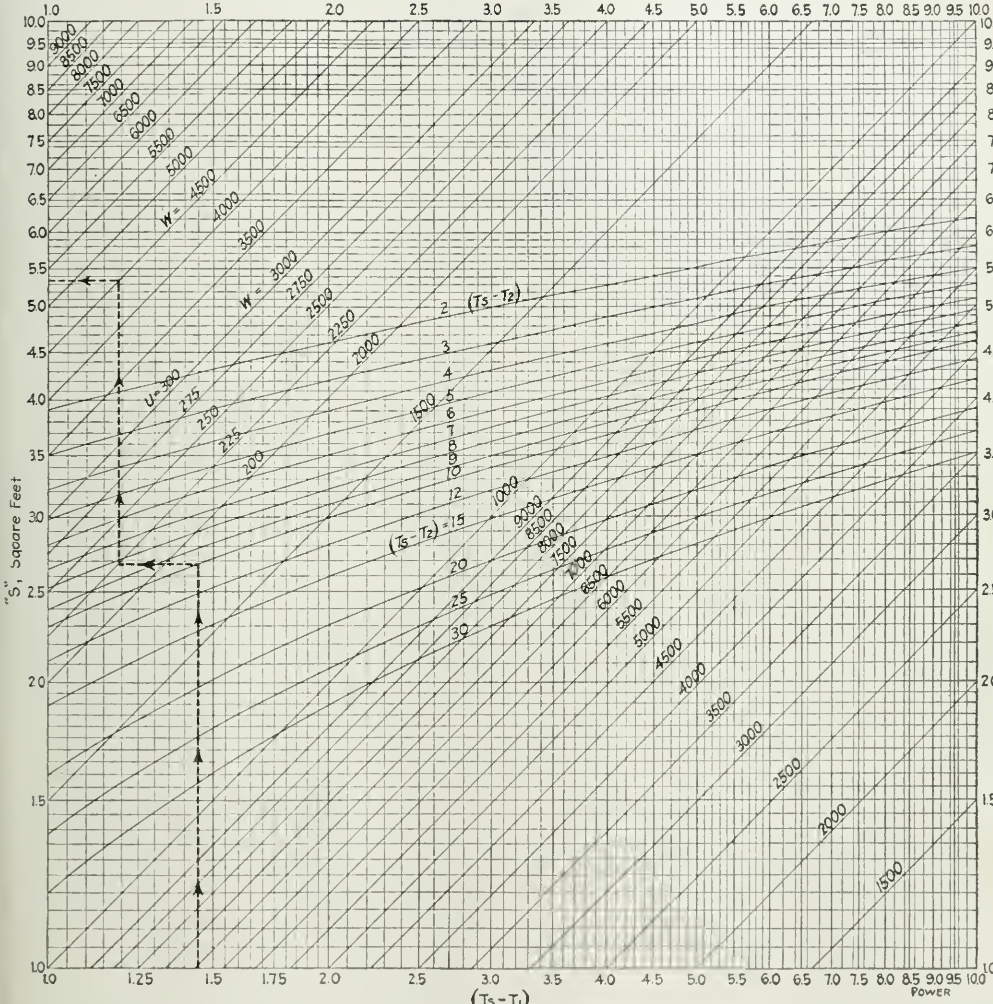


FIG. 2. CHART FOR FEED-WATER HEATERS

$$S = \frac{W(T_2 - T_1)}{U\left(\dfrac{T_2 - T_1}{\log_e \dfrac{T_s - T_1}{T_s - T_1}}\right)}$$

where S = square feet of heating surface; W = pounds of water per hour; T_s = temperature of steam; T_1 = inlet temperature of water; T_2 = outlet temperature of water; U = B.t.u. transmitted per square foot per hour per degree difference of temperature.

U = B.t.u. transmitted per hour per degree difference of temperature per square foot;

L = Latent heat in steam corresponding to its temperature;

W = Pounds of steam condensed per hour;

w = Pounds of water heated per hour;

D = Mean difference in temperature between water and steam;

$$USD = WL$$

$$S = \frac{WL}{U\left(\dfrac{T_2 - T_1}{\log_e \dfrac{T_s - T_1}{T_s - T_2}}\right)}$$

This is a cumbersome formula to use or plot, but the function

$$\left\{ \frac{T_2 - T_1}{log_e \frac{T_s - T_1}{T_s - T_2}} \right\}$$

which contains three variables, may be simplified by letting $(T_2 - T_1) = a$ and $(T_s - T_1) = b$, whence

$$D = \frac{T_2 - T_1}{log_e \frac{T_s - T_1}{(T_s - T_1) - (T_2 - T_1)}} = \frac{a}{log_e \frac{b}{b - a}}$$

Now assume values for a and b and solve for D, obtaining a series of curves as shown on Chart No. 1. Having found D, the formula is of simple form, which plots in straight lines on logarithmic paper.

Example 1: To condense 70,000 lb. of steam per hour and produce a 28-in. vacuum (referred to a 30-in. barometer) with circulating water at 70° F.

Assume the temperature of the water leaving the condenser to be 10 deg. cooler than the incoming steam, $T_s - 10 = T_2 = 91.5$. Let the heat transmitted per hour per degree difference of temperature per square foot be 350 B.t.u. Then,

$W = 70{,}000$;
$T_s = 101.5$ deg. F.;
$T_2 = 91.5$ deg.;
$T_1 = 70$ deg.;
$U = 350$;
$(T_s - T_1) = 31.5$ deg.;
$(T_2 - T_1) = 21.5$ deg.

Enter Chart No. 1 at 21.5 on the base, the value of $(T_2 - T_1)$ and extend vertically, as shown by the dotted line, to 31.5, the value $(T_s - T_1)$; read horizontally to 350 the value of U; vertically to 70,000, the value of W (70 being the same as 70,000 on logarithmic paper); horizontally to the edge of the chart and read 10,670, the number of square feet of cooling surface required.

In accordance with commercial practice of the condenser builders, the value L has been taken as 1000, which corresponds closely to the heat content of steam in the condenser, which, before entering the turbine, had 175 lb. pressure and 100 deg. superheat. The value L would be about 950 for steam entering the turbine at 150 lb. dry and 900 if entering the turbine dry, but at a pressure of about 5 lb. gage. Therefore, for the two latter conditions, 5 and 10 per cent., respectively, should be deducted from the final value obtained.

CIRCULATING-WATER RATIO

The actual ratio of circulating water to condensed steam is determined by the formula

$$R = \frac{f\,L + q - (T_c - 32)}{T_2 - T_1}$$

Where R = Pounds of circulating water per pound of steam:
f = Quality of the steam;
L = Latent heat of the steam;
q = Heat of the liquid in the steam;
T_c = Temperature of condensate;
T_2 and T_1 as before.

Due to the large difference in capacities between the different commercial pump sizes available, this formula may, for practical use, be written

$$R = \frac{L}{T_2 - T_1}$$

using the same values of L as before.

Assume the same problem and start at the base of Chart No. 1 at 21.5, the value of $(T_2 - T_1)$; follow vertically to the longest diagonal marked L (10); then horizontally to side of the chart and read 46.5, the value of R. Therefore, to condense 70,000 lb. of steam per hour and produce a vacuum of 28 in.,

$$\frac{70{,}000 \times 46.5}{8\frac{1}{3} \times 60} = 6510 \textit{ gallons per minute}$$

of circulating water at 70 deg. is required.

FEED-WATER HEATERS

The function of this apparatus is similar to a surface condenser and its heat balance may be expressed as follows:

$$U\,S\,D = w\,(T_2 - T_1)$$

$$\text{or} \qquad S = \frac{w\,(T_2 - T_1)}{U \left(\frac{T_2 - T_1}{log_e \frac{T_s - T_1}{T_s - T_2}} \right)} = \frac{log_e \frac{T_s - T_1}{T_s - T_2}\,w}{U}$$

$$\text{or} \qquad \frac{S\,U}{w} = log_e \frac{T_s - T_1}{T_s - T_2}$$

Assuming values for $(T_s - T_1)$ and $(T_s - T_2)$, the curves shown on Chart No. 2 are obtained. Calling the value $log_e \frac{T_s - T_2}{T_s - T_2}$, k, the formula becomes $S = \frac{K\ w}{U}$, which, as before, can be plotted as straight lines on logarithmic paper.

Example 2: To heat 45,000 lb. water per hour from 67 to 202 deg. with ample exhaust steam available at 212 deg. F. We have

$W = 45000$ *Assume* $U = 225$
$T_s = 212$ $(T_s - T_1) = 145$
$T_2 = 202$ $(T_s - T_2) = 10$
$T_1 = 67$

Begin at 1.45 at the base of the chart, value of $(T_s - T_1)$; and read vertically to 10, the value of $(T_s - T_2)$; then horizontally to 2.25, the assumed value of U; now vertically to 45,000, the value of w, and horizontally to the edge of the chart and find 535, the number of square feet of heating surface required.

⁂

For the Engineer's "Don't Book"—Some don'ts from the book of instructions issued by the Susquehanna Coal Co. which are equally good for the engineers' don't book:

Don't forget that thorough and efficient examinations and inspections before accidents bring better results than the same work after an accident.

Don't forget to help educate the employees to take care of themselves.

Don't wait for the general inspector to point out dangerous conditions.

Don't fail to take every precaution to insure the safety of the workmen.

Don't fail to have investigated at once any dangerous conditions reported to you.

Don't employ a man for work with which he is not familiar without giving him instructions.

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*When R=50, the gallons of water per minute is one-tenth of the pounds of steam condensed per hour.

Motors, Their Principles and Uses--VI

By Gordon Fox

SYNOPSIS—The concluding article of the series, taking up electrical features of motor installations, including starters, protective devices and methods of wiring.

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Upon the driving equipment of a factory depends its entire productive capacity, and in order to guarantee reliability, all electrical equipment must be installed in a thorough manner. The decreased cost for maintenance will more than offset any extra costs incurred in a first-class initial installation.

Next to the motor itself, the control equipment is of first importance. This is often a point of weakness and it is possible to greatly impair both the effectiveness and the reliability of a drive by control devices not best suited to the requirements.

The principles of direct-current starting boxes and control panels were discussed in an earlier article,* although a few details deserve attention at this point. The ordinary control equipment of a direct-current motor consists of a starting box, a switch and a fuse cutout. There are on the market simple slate panels, upon which are mounted various types of starters, together with a switch and fuses or with a double-pole circuit-breaker. The circuit-breaker type is preferable, except for widely fluctuating loads or where heavy starting current is required. The panel board is compact, inexpensive and easily installed and the cost of upkeep is low.

Ordinary starters are designed for moderate duty at infrequent intervals. Where heavy loads are to be accelerated or where repeated starting is required, special resistance must be furnished. Starters of the sliding-contact type must necessarily have a large number of resistance steps in order to reduce the arcing occurring when the lever is moved from one segment to another. In the larger sizes it is difficult to prevent all arcing and also to obtain good contacts. Multiple-switch starters are preferable for heavy work, since little or no arcing occurs, and excellent contacts are secured through the use of laminated brush construction, in which case it is not necessary to provide as many resistance steps.

Drum-type controllers are commonly used where continuous or frequent control is desired, as they are more durable. They are best suited for variable-speed machine-tool work and for all dirty locations. A drum controller can be mounted readily at any point on the driven machine and, if inaccessible to the operator, a chain drive, spur gear, bevel gears, rack-and-pinion or swivel-joint device can be arranged to bring the point of control to the desired location. They are not ordinarily fitted with protective devices, but where desired, a no-voltage release and circuit-breaker can be furnished. More commonly, a fused switch is used.

Where direct-current motors are to have their speed controlled by the armature-resistance method, it is important that the resistance be properly apportioned to the load. The speed of the motor depends upon the voltage at its terminals. This, in turn, is dependent upon the resistance drop, and the latter is proportional to the current. If the resistance is not properly proportioned for all loads, then the speeds will not be correct. Consider a case in which a 10-hp. motor, rated at 1200/600 r.p.m., drives a printing press. This is approximately a constant-torque drive and the load varies directly with the speed. Assume that the motor requires 4 hp. at low speed. The resistance is designed to reduce the armature voltage from line pressure, 220 volts, to about 110 volts, so that the motor will run at half speed. The resistance drop will be correct only if the load be 5 hp. With 4 hp. there will be about 88 volts drop, and the speed will be about 750 r.p.m. The load will increase somewhat so that the speed will not be as great as this, but it will materially exceed 600 r.p.m., as desired.

This point may be made more clear by means of a set of curves, as shown in Fig. 1. Curve *A* shows the speed regulation with full voltage at the armature; curve *B*, with a small resistance inserted, and curve *D* with all the resistance inserted. It is evident that for a given load, for instance 5 hp., the speed will depend upon the resistance. Also with a large amount of resistance in the armature circuit the speed varies widely with the load. To obtain a desired speed, at a designated load, it is necessary that the resistance be of the proper value. This should illustrate the necessity of carefully predetermining load conditions for machines using this type of control and arranging the control resistance in accord with the requirements.

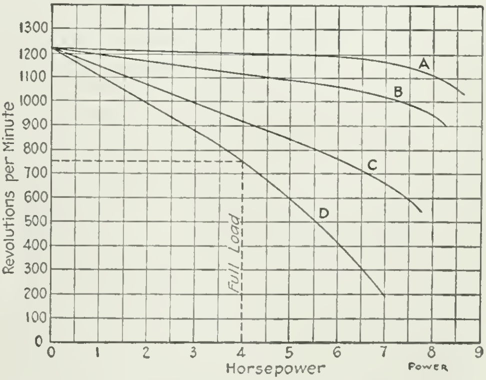

Fig. 1. Speed Load Characteristics for 0, 10, 30 and 50 per Cent. Armature Resistance

Direct-current motors having their speed controlled by the field-resistance method, have a definite speed at each controller point, changes in load having little effect. Therefore, the points above mentioned concerning armature control do not apply in the same manner. It is necessary, however, to consider the relations of power to speed to prevent seriously overloading the motor at any point in its range. For this service, controllers in which armature and field resistance are both included in the same unit are preferable, since an interlocking device is provided which insures starting the motor under full field. If the motor be started with a weak field, a much heavier current is required for a given torque, since the magnetic intensity, a component of torque, is low.

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*See "Power," page 448, Sept. 29, 1914.

Polyphase alternating-current motors up to and including 3 hp. are generally provided with a simple single-throw switch, and the fuses are made sufficiently heavy to withstand the rush of current at starting. As there is usually little inertia to these light drives, the accelerating period is short and the fuses will not blow. Five-horsepower motors are generally started by means of double-throw switches, fused on the running side only. This arrangement is also used for smaller motors where the starting load is heavy. Squirrel-cage motors larger than 5 hp., which are to accelerate under load, should be started under reduced voltage. Seven and one-half-horsepower motors driving fans or otherwise starting light, may be started on full voltage with a double-throw switch in some cases where voltage regulation is unimportant. Voltage reduction during the starting period is obtained through auto transformers, called compensators, through insertion of resistance, in the primary circuit, by taps in supply transformers and by star-delta connection of motors.

The compensator permits a selection of voltage to correspond with the starting torque required. It is efficient and reliable, and the switch is immersed in oil, thus decreasing the arcing at the contacts. Resistance starters usually have air-contact devices, but they do not reduce the starting current as effectively as compensators, due to the loss of power in the resistance. A simple starter of this type is that using variable-pressure carbon cylinders for resistance. This is quite satisfactory for motors of small size. The use of taps from the supply transformers is feasible for a few installations. Usually half-voltage taps are the only ones available. With only half voltage impressed upon the motor, its torque is low, so that this practice is confined to motors starting under light loads. The star-delta method is attained by the use of special winding connections, allowing two groupings of the stator coils, and it is necessary to carry out six leads from the motor to the switch. This arrangement also provides but one value of starting voltage, and it is adapted for light starting work only.

In selecting starting devices, attention should be given to those points calculated to render the device foolproof. In the case of compensators it should be impossible to throw the motor to running position without pausing at the starting position. It should also be impossible to leave the handle at the starting point. The interlocking devices on the best types of commercial compensators furnish this protection. No-voltage release devices are on the compensators only. Some manufacturers furnish them only as an extra. They protect the motor by throwing the compensator to the off position in case of failure of the voltage. Then, when the service is again continued, the motor must be manually started; without this protection it would receive full line pressure while at rest and serious injury might result.

Slip-ring motors are started with full voltage impressed upon the primary circuit and resistance is inserted in the secondary circuit. Inasmuch as the rotor or secondary circuit has high resistance during the accelerating period, its current is reduced and that taken from the line by transformer action is lessened. As the motor speeds up, the resistance may be cut out until full speed is reached with the controller short-circuited. Comparatively heavy starting torques can be obtained by this method with attendant low starting currents. The method is desirable for very heavy starting service. When slip-ring motors are used for variable-speed service they act similarly to direct-current motors with armature resistance. The points mentioned in that connection with regard to the relations of speed to load apply to these motors also.

Overload protection for any motor may be had through the use of fuses, circuit-breakers, overload releases and time-limit relays. Fuses have the advantage of low first cost and the disadvantages of high maintenance expense and delays for renewals. Their ability to withstand instantaneous peaks without blowing is a point of value. They are rated at maximum continuous-current carrying capacity, and will usually blow at current values about 25 per cent. above their rating, depending upon the condition and duration of the load. Table 1 shows the standard sizes of fuses interchangeable in the same clips. It is advantageous to have different ratings of the same size of different colors so that a casual glance will detect any substitution.

TABLE 1. INTERCHANGEABLE FUSES FOR STANDARD CUTOUTS

Cutout Rating	Standard Fuse Sizes, Amperes
30 amperes......	1—2—3—4—5—6—7—8—9—10—12—15—20—25—30
60 amperes......	35—40—45—50—55—60
100 amperes......	65—70—75—80—90—100
200 amperes......	110—120—130—140—150—160—170—180—190—200
400 amperes......	225—250—275—300—325—350—375—400
600 amperes......	425—450—475—500—525—550—575—600

Circuit-breakers are commonly used, especially on direct-current circuits; they afford excellent protection, cause minimum delay to the service, eliminate costly fuse renewals; they can be made to break heavy currents safely and with minimum arcing; they can be arranged to signal in case of opening, but their instantaneous action renders them unsuited for some fluctuating loads.

Overload release coils are provided on some direct-current starting boxes and alternating-current compensators in place of fuses. They usually operate by short-circuiting the no-voltage release magnet. In the larger sizes of direct-current starters the no-voltage release coil actuates the overload-release device which is similar to a circuit-breaker. This arrangement is necessary to prevent destructive arcing at the first segment. In connection with alternating-current compensators, no-voltage and overload-release attachments are useful and should be used for most large sizes, due to their ability to eliminate costly fuse renewals. Definite time-limit and inverse time-limit relays, as their names imply, will carry instantaneous peaks but will operate under maintained overloads. They operate similarly to overload-release coils and are well adapted to service where fluctuating loads occur.

The wiring layout of a factory is, of course, a matter depending largely upon local conditions, the details of each installation requiring special consideration. The subject will be treated in a general way and data given to assist in making calculations.

In any factory of considerable size, it is practically compulsory that the power and lighting-distribution systems be separate; this is necessary to secure satisfactorily uniform lighting service, reliability and independence. The usual power voltages are 220 and 440, and the best lighting voltage 110, inasmuch as tungsten lamps may be used. With isolated direct-current plants, this can be accomplished with a three-wire generator and compensator. If 220-volt direct-current service only is available, it is frequently best to install a small balancer set and distribute through a three-wire system. Where alternating current is used, it is a simple matter to transform to the desired voltage. If the system is polyphase, it is best to arrange to approximately balance the lighting load on the phases if this load exceeds 10 per cent of the motor load. Two transformers or autotransformers are necessary to accomplish this result. The latter are cheaper, while the former add an insulating link in the installation.

A large plant should be divided into sections usually corresponding to departments or buildings. Each division should have its separate feeder circuit. This system gives maximum reliability through isolation of circuits, it affords centralized control, uniform voltage at all points, flexibility and ease of extension through the use of additional feeders and permits a check upon power consumption of departments if desired.

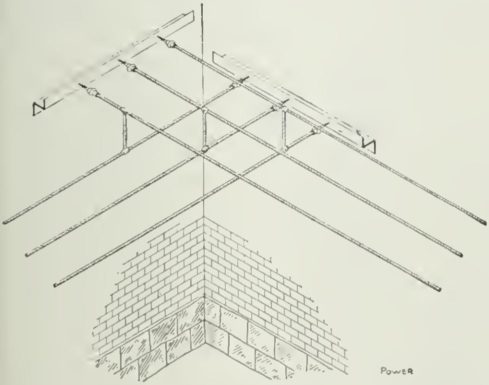


Fig. 2. One Method of Making Right-Angled Turn in Line

The most advantageous location for distribution wiring is upon the ceilings below the floors fed. Where motors are wall or ceiling mounted the distribution wiring can be readily carried upon the same ceiling. Where the installation is mixed it is often best to maintain the layout plan and possibly isolate the floors. This plan may not be necessary and, in many cases, one set of feeders may suffice for ceiling motors as well as machines on the floor above. In a single-story building with timber flooring, circuits beneath the floor may or may not be advisable, depending partly upon accessibility. Where there are concrete floors, the wiring may be in concealed conduits or tunnels. It is not desirable, however, if the machines are frequently relocated. In such cases a checkerboard connecting-in system may be arranged if the expense is warranted.

Open wiring is employed extensively for heavy work, heavy circuits being handled usually through the use of single-conductor cable. The best type of construction is that employing straight line layouts with the feeders dead ended at the extremities of a run through strain insulators. Split eyes support the cable and keep it in line but they do not clamp it. Where a turn is desired, one set of wires crosses the other at a different elevation and jumpers connect the points desired. This arrangement is shown in Fig. 2. Lighter wires may be run neatly by the use of the ordinary clamping cleats. Care should be taken to maintain good tension, support the wires at intervals not greater than 4½ ft. and do all work thoroughly. Considerable light wiring is being done by the use of multiple-conductor cable, thus lowering the work of installation materially; in many places this practice is to be commended.

Conduit work is desirable in a factory for all light work involving the use of No. 6 B. & S. wire or below. It should be used for all wiring exposed to injury, hence for most vertical runs, on posts and about machines. Conduit may also be advantageous in places exposed to moisture, acids or fumes; the ends being sealed with wax or rosin. The usual rules for conduit work should be met. For alternating-current work all wires must be in the same conduit, and for direct-current work this practice is desirable. Splices must not be pulled into the conduit.

For work involving copper heavier than No. 8, B. & S. gage, stranded cable should be used. Table 2 shows the conduit sizes required for numbers of wires based on runs having not more than 4 ninety-degree turns.

TABLE 2. CONDUIT SIZES, INCHES

	B. & S. Gage or Circ. Mils.	2 Wires	3 Wires	4 Wires	5 Wires	6 Wires
Solid	12	¾	¾	¾	1	1
	10	¾	¾	1	1	1¼
	8	¾	1	1	1¼	1¼
Stranded	6	1	1¼	1¼	1½	1½
	5	1¼	1¼	1¼	1½	2
	4	1¼	1¼	1½	1½	2
	3	1¼	1¼	1½	2	2
	2	1½	1½	2	2	2½
	1	1½	2	2	2½	2½
	0	2	2	2	2½	3
	00	2	2	2½	2½	3
	000	2	2	2½	3	3
	0000	2	2½	3	3	3½
	250,000	2½	2½	3	3½	3½
	300,000	2½	3	3	3½	4
	350,000	3	3	3½	3½	4
	400,000	3	3	3½	4	4½
	500,000	3	3½	3½	4	4½

Flexible metal conduit is excellent about machines for motor and controller leads. It is easily installed and fitted into out-of-the-way locations. While loom is sometimes used for this work, it is inferior.

The proper wire sizes for power distribution depend upon heating and upon resistance and reactance voltage drop. For short runs the former is the limiting feature but for long circuits of No. 0 wire or larger, carrying alternating current, the reactance drop must be considered, particularly where the wires are spaced some distance apart. Tables of values of impedance drop in various circuits are given in electrical handbooks. In circuits of large wire the reactance drop may equal or exceed the resistance drop.

The permissible voltage drop varies according to the source and cost of power, distance of transmission and character of load. In the case of an isolated plant, where the feeder system is properly laid out, it may be allowable to run the generator at a voltage as much as ten per cent. above motor rating and permit this drop in the distribution circuits. In most instances, a lower drop must be figured. The motors must have full rated voltage, or nearly so, especially if they carry overloads or require good starting torque, as these quantities vary as the square of the voltage. Theoretically, the drop should depend upon the comparative cost of power and copper.

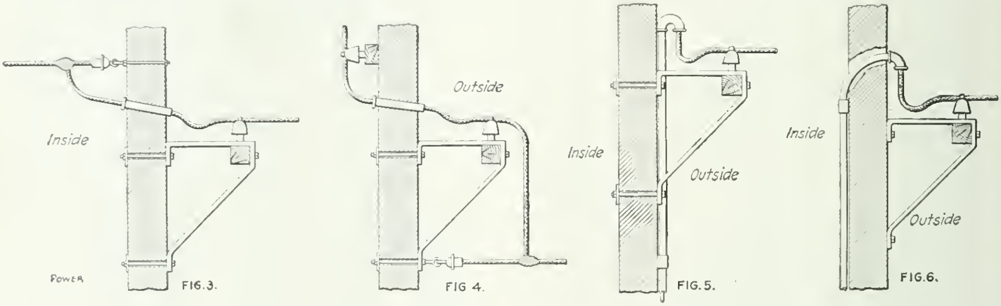
The percentage of power loss corresponds approximately to the percentage of resistance drop. If the power loss per annum is made equal to the interest on copper per annum, the system is supposed to represent the best investment. Wherever there is a probability of future extension or a possibility of replacing a motor or motors by larger sizes, the wiring should be installed to handle the heavier service.

For the sake of facilitating estimates, Table 3 is given, showing full-load current ratings of motors of different types. These values must be increased by 25 per cent. before figuring the wire sizes; this provides for starting currents and overloads. The Underwriters require that wiring be designed for 125 per cent. full-load current ratings and the fuses shall have a rating not higher than the listed current capacity of the wires they protect.

TABLE 3. APPROXIMATE AMPERES PER TERMINAL FOR MOTORS

Hp. of Motor	220 Volts Dir. Current	220 Volts Single-Phase	220 Volts 2-Phase	220 Volts 3-Phase
1	4.3	6.2	3	3.2
2	8	10	5	6
3	11.8	15	7.5	9
5	19	26	13	15
7½	29	40	20	22
10	37.5	50	25	29
15	50	70	35	41
20	75	..	48	55
25	95	..	54	62
35	133	..	80	93
50	188	..	110	127
75	280	..	165	192
100	373	..	215	248
200	738	..	410	475

For other voltages multiply by $\frac{220}{\text{voltage}}$



Figs. 3 to 6. Methods of Leading Wires into Buildings

For plants where miscellaneously scattered points are to be fed it is often advantageous to carry most of the distribution system outside where it is more accessible and better maintained. Usually the wiring is rather heavy in character. Circuits may be carried on poles or on brackets attached to the buildings; the former practice is often preferable, but more expensive. For large cable straddle-type insulators should be used. The practice of dead-ending through strain insulators can often be advantageously followed, making a neat and substantial job. Circuits should be protected by lightning arresters at points of entering buildings. The method of entrance depends largely upon the weight of wire and type of construction; Figs. 3, 4, 5 and 6 are included by way of suggestion.

Supply transformers may be in a separate fireproof building or they may be mounted on poles. Very large transformers are best installed by the first method; the cases should then be grounded. Transformers mounted on poles are best placed on platforms using two, three or four poles as legs, depending upon the weight. Care should be exercised to place the transformers advantageously, so as to save secondary copper.

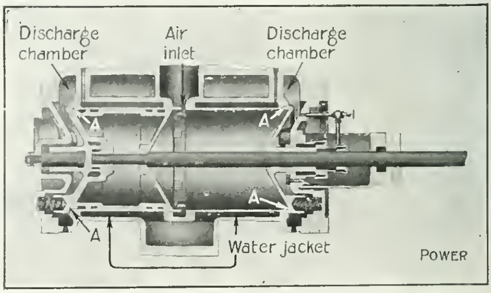
⁂

An Air Pump with No Clearance

An air pump, invented by E. W. Christie, mechanical engineer of the Wheeler Condenser & Engineering Co., at Carteret, N. J., solves the question of clearance by using a central belt port (like the Unaflow engine's exhaust) for an inlet port and making the cylinder head the exhaust valve.

Referring to the accompanying section, when the piston is at the end of its stroke the central port is uncovered and the cylinder fills with air and vapor of the pressure existing in the condenser, together with some water. The first movement of the piston on the return stroke covers this port and the air and vapor are compressed and, with the water, discharged at *AA* when the head which forms a discharge valve is lifted from its seat against the tension of the seating springs. The movable heads are made to fit closely into the piston so that the clearance is eliminated.

The cylinder barrel is completely water-jacketed except at the air-inlet ports. The pump is of the "wet air" type, removing both air and condensate, but may be used for air only by furnishing a slight amount of sealing water. It is adapted to either the crank-and-flywheel construction or for connection to direct-acting steam cylinders, with which, regardless of the variable stroke, the air is completely discharged and a high vacuum is thereby main-



An Air Pump without Clearance

tained. The combined equipment—direct-acting air and condensate pump at one end, steam cylinder in the center and direct-acting circulating pump at the other end—usually good for 25 to 26 in. of vacuum—will, with the Christie pump, maintain a vacuum of 28 in. or more. In tests at the shop, guaranteed performances of 28 in. with 80-deg. water are easily surpassed. A higher vacuum result was as follows:

Barometer	30.2 in. mercury
Vacuum attained	29.4 in. mercury
Pressure in condenser (abs.)	0.8 in. mercury
Temperature sealing water	60.0 deg. F.
Pressure corresponding to 60 deg. F.	0.522
Pressure in excess of that of vapor	0.278

The pressure in the condenser was less than 0.3 of an inch more than the vapor tension due to the temperature of the sealing water, showing that the pump maintains a vacuum nearly the theoretical maximum.

⁂

Chain Grates under Vertically Baffled Water-Tube Boilers*

By Osborn Monnett†

SYNOPSIS—With a properly designed arch and a restricted throat opening, it is possible to secure a smokeless setting up to 50 per cent. overload. Minimum head room for water-tube boilers of different tube pitch equipped with different types of stoker.

⁂

The vertically baffled water-tube boiler setting with a chain grate requires more careful study than the horizontally baffled setting. Cases have been known where two apparently identical settings have for some inexplicable reason shown widely different results, one being a success and the other a failure. There seems to be less certainty of smokelessness with the vertical baffle, owing to the dampening action on combustion of the bank of tubes over which the flames must pass if the flame travel is short.

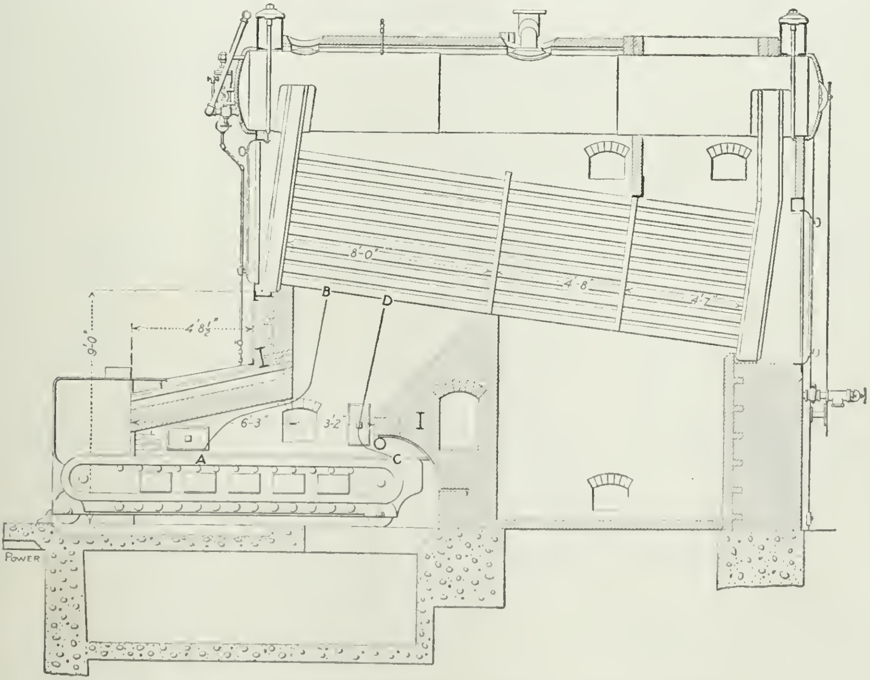


Fig. 1. Faulty Chain Grate Installation with Vertical Baffles

For high capacities, 100 per cent. overload and above, the vertical baffle has been abandoned entirely on account of smoke trouble, and some type of the previously described tile-roof furnace substituted. For loads up to 50 per cent. above rating, a number of vertically baffled settings have been successful, and there is no question but that they will give satisfaction if properly designed.

There is considerable objection to the chain grate among many engineers on the grounds of inefficiency. This is due to the characteristic weakness of the chain grate in allowing air to enter through the back portion of the grate and around under the water-back. Improp-

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*Copyright, 1914, by Osborn Monnett.
†Smoke Inspector, city of Chicago.

erly installed, the chain grate is wasteful. Properly installed, it can be made efficient. For example, take Fig. 1. As the coal passes under the arch and ignition occurs, the volatile matter begins to distill off. Following the lines of least resistance, it flows along the under side of the arch and passes into the heating surface, as shown by the line *A-B*. At the same time, air is entering through the back end of the grate and through the opening under the water-back, and passing into the heating surface along the line *C-D*. Thus, if the volatile matter, which will burn if supplied with air, and the necessary air to burn it are entering the furnace at points so widely separated that they do not mix, an inefficient, smoky setting is the result If the throat of the furnace is closed up to 30 in. between the bridge-wall and the end of the ignition arch, and the bridge-wall is brought up vertically to a point above the end of the ignition arch, the air entering around the water-back will be forced to mingle with the volatile matter in a zone of high temperature This will produce a Bunsen burner effect, resulting in a smokeless furnace and high economy. The vertical bridge-wall has a beneficial effect not only on smoke, but on the capacity to burn coal. The radiating effect of the bridge-wall helps to consume the incandescent carbon on the grates so that there is no danger, at any reasonable capacity, of live coals getting into the ashpit. The most economical way to run a chain grate is to have the grate covered and so adjusted that there will be a small amount of incandescent matter, mostly redhot ashes, falling into the ashpit.

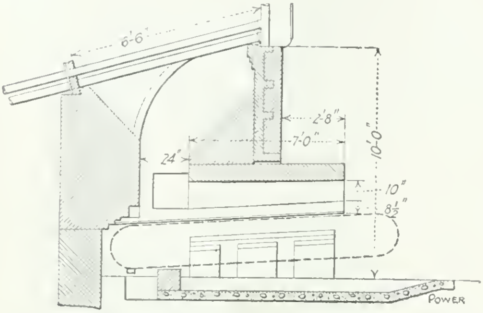


FIG. 2. B. & W. BOILER, 500 HP., WITH LACLEDE-CHRISTY CHAIN GRATE AND SPRUNG ARCH SET HORIZONTALLY

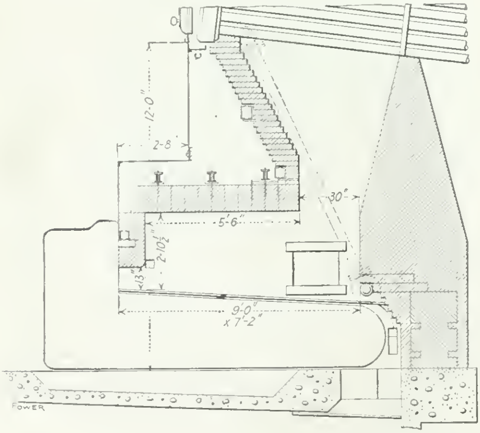


FIG. 3. HIGH FLAT ARCH WITH VERTICAL BRIDGE-WALL AND 30-IN. THROAT OPENING, 350-HP. UNIT

One of the valuable points to be brought out in Fig. 2 is the fact that it is not necessary to install a chain grate full extension with a vertically baffled boiler to get a satisfactory setting. This is important when floor space is at a premium. In this case, the extension is only 2 ft. 8½ in. to the gate, while the arch is 7 ft. long, giving a 24-in. throat opening. As a matter of fact, having the grate to some extent under the boiler enables the designer to locate the bridge-wall at a more favorable point with respect to the first baffle, and also makes it possible to get a better bridge-wall action than can be obtained with a full extension furnace. The throat area can be made small enough to insure that the volatile matter and the air from the rear will become intimately mixed in the zone of high temperature. In this particular installation, the throat has been restricted more than usual, and the reduction in area has reached the limits of economy.

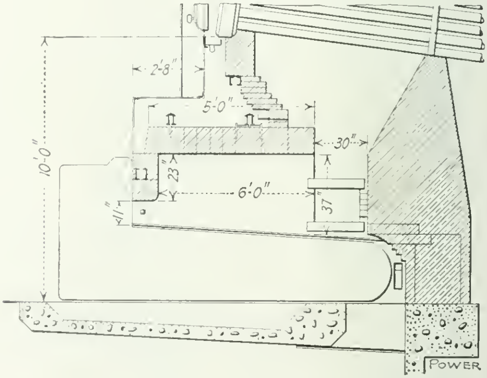


FIG. 4. ANOTHER TYPICAL FLAT-ARCH INSTALLATION WITH GOOD BRIDGE-WALL ACTION, 300-HP. UNIT

Another type of arch which has worked out well is shown in Fig. 3. It is installed under a 350-hp. Oil City boiler, equipped with an Illinois chain grate having a flat arch. Inside the gate there is a 12-in. arch set 13 in. above the level of the grate. Above is a 5-ft. 6-in. arch set 34½ in. over the grate, as indicated. The effort here has been made to provide unusual volume in the furnace to take care of large amounts of volatile matter. The bridge-wall is built vertical and the throat opening is 30 in. Fig. 4 shows another typical setting with this type of arch, which is good for 50 per cent. overload.

MINIMUM HEIGHTS

The height of a setting is generally measured from the floor to the bottom of the front header by engineers, architects and contractors, who invariably want to know the minimum height in which a setting will make good. For this reason, it has become necessary to fix the heights of various combinations based on experience with successful settings. To do this, a standard set of conditions has been assumed as follows:

1. Water-back to be set 5 ft. from the inside of the front header.

2. The flame travel to be measured from a point 3 ft. in front of the water-back.

3. The distance from the latter point to the nearest heating surface to be a minimum of 7 ft.

Using the above conditions as a standard, the set of drawings shown in Fig. 5 were worked out for different stokers and tube pitches, showing the height from the floor line to the bottom of the first tube. These heights represent actual minimum conditions under which satisfactory installations may be expected, up to 50 per cent. overload, when using a successful type of arch construction, a vertical bridge-wall and a 30-in. throat opening.

It is always desirable to give dimensions in round numbers if possible, and in such shape that brick masons can work to them conveniently. From the data given, two general rules can be deduced which meet approximately the standard conditions above expressed, any variation being due to the slight difference in height of stokers and the construction of the front header in different boilers.

1. All boilers having a tube pitch of 3¼ in. to the foot, 10 ft. under the front header.

2. All boilers with a tube pitch less than 3¼ in. to the foot, 9 ft. 6 in. under the front header.

All types of arch will not be a success under the above conditions. The best ones have been the sprung arch placed horizontally, and the high, flat arch similar to that shown in Figs. 3 and 4. The step-up arch has not always worked out successfully, as it gives a poor throat opening and bridge-wall action, and the single inclined flat arch is still a doubtful proposition with these minimum dimensions on vertical baffles. Enough experience has been had with the two types first named to know that they will make good.

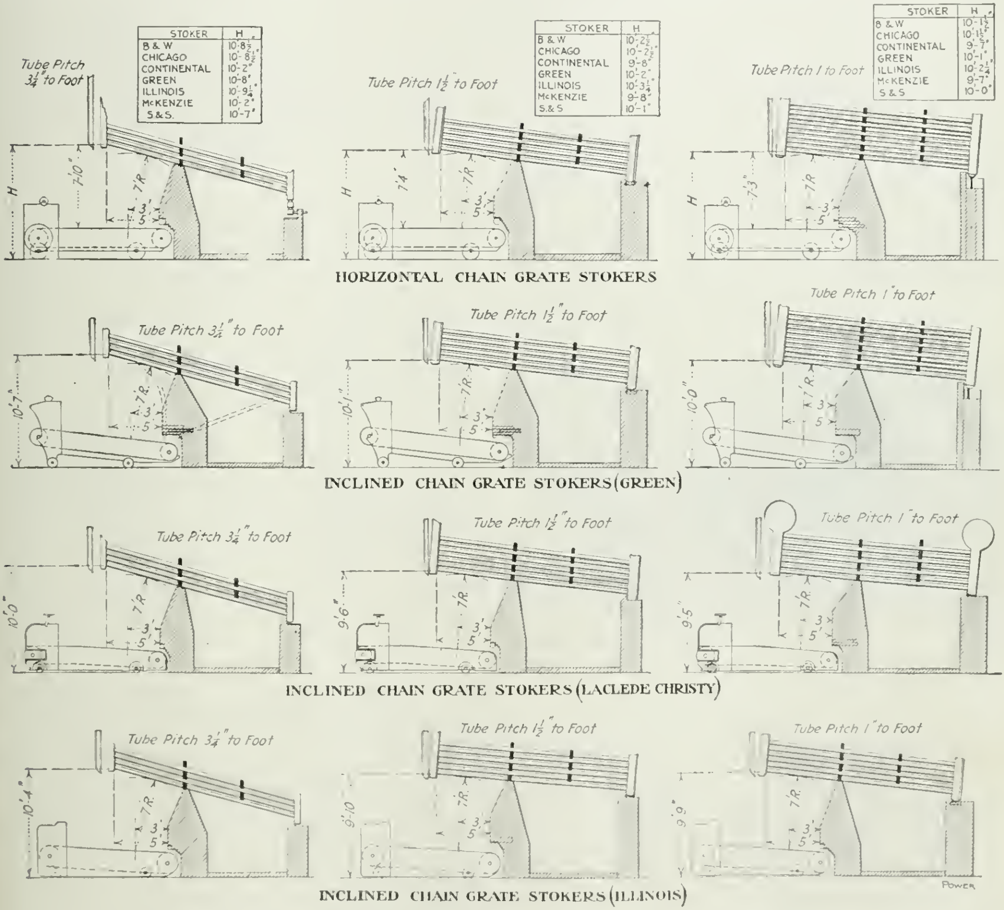


Fig. 5. Standard Minimum Head Room for Vertically Baffled Water-Tube Boilers and Chain Grates

⁂

Overtime Work—The engineer should keep his work well in hand so that overtime work for repairs, etc., may be avoided. Such work is usually at a higher rate and, being carried on after hours, is frequently poorly done.

"Giant" Fuel-Oil Engine

A fuel-oil engine operating on the two-stroke cycle has been placed on the market by the Chicago Pneumatic Tool Co., of Chicago, Ill. Primarily, it is intended for driving air compressors for portable and stationary service, but with regulation within 3 per cent. as claimed, it could be used for generator driving or general power purposes. It is built in sizes from 12 to 45 hp. and with twin arrangement these capacities are doubled. The fuel may be of any grade between crude oil and gasoline. The absence of valves and gearing, igniters, spark plugs, etc., results in a simple engine capable of withstanding hard usage.

The engine, which is shown in Fig. 1, has a heavy inclosed frame and in accordance with the latest designs is provided with a crosshead. The front, or crank end of the cylinder is inclosed, with a stuffing-box for the piston rod, the charge of air for the combustion chamber being compressed in this space. This air is admitted through a port uncovered by the piston at the end of the out stroke. On the return stroke, it is compressed to about 6 lb. pressure, and when the port to the combustion chamber at the top of the cylinder is uncovered by the piston, it rushes into the cylinder, pushing the exhaust gases through the port shown in Fig. 2 at the bottom of the cylinder. On the out stroke the charge of fresh air in the combustion chamber is compressed to about 150 lb. As the piston reaches the end of the stroke a charge of oil is injected in a fine spray onto an ignition plate attached to the piston and as it is heated during compression and by previous explosions, this plate gasifies and ignites the fuel. A hot tube is provided for starting.

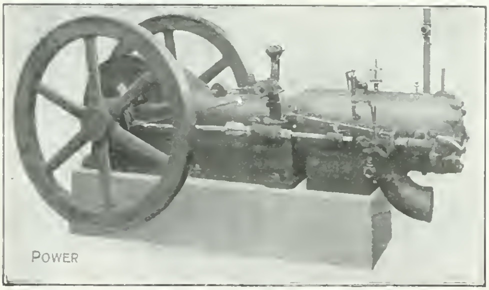


FIG. 1. "GIANT" FUEL-OIL ENGINE

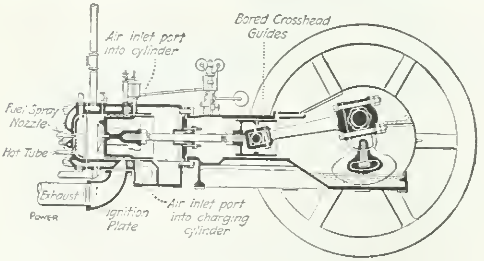


FIG. 2. SECTION THROUGH ENGINE

The small engines may be started by hand, but for the larger sizes a small vertical single-acting air compressor, driven from a pulley bolted to the flywheel, is used. The compressor delivers air at 150-lb. pressure to a storage receiver which is of sufficient volume to run the engine on air until firing of the fuel charge begins, after which the air is shut off.

A plunger pump of simple construction, Fig. 3, supplies the oil to the engine at the center of the cylinder head through the spray nozzle shown in Fig. 4; by means of screw plugs both are easily accessible. Regulation of the pump stroke is accomplished by a cam under the control of a flyball governor belted to the main shaft. The cam rests against a collar on the pump plunger, its position determining the stroke of the pump and consequently the quantity of fuel injected. A hand-operated lever also acting upon the plunger is provided for stopping the engine. The working stroke of the pump is effected by an eccentric on the main shaft through a reach rod coming in contact with the end of the plunger, which is returned by a spring; the arrangement is shown in Fig. 1.

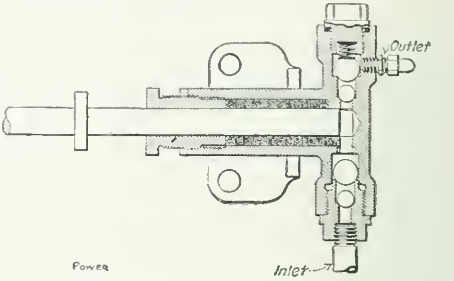


FIG. 3. OIL PUMP

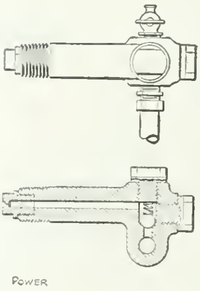


FIG. 4. OIL SPRAY NOZZLE

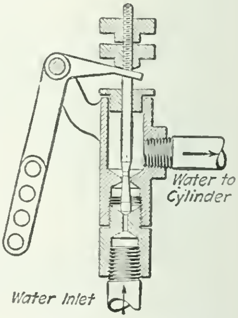


FIG. 5. WATER REGULATOR

To prevent overheating of the piston head and the burning of the lubricating oil, water is injected into the cylinder to mix with the fuel. Its supply is in proportion to the load and the quantity of fuel injected is controlled by the regulator shown in Fig. 5. The latter is also attached to the governor.

As is shown in Fig. 2, the combustion chamber and the cylinder head are water-jacketed. A sight-feed oiler lubricates the cylinder and in the crank case splash lubrication is employed. The crank is counter-balanced, and as far as the crosshead, the construction follows closely steam-engine design.

Editorials

The Jersey License Situation

On another page of this issue, A. L. Case replies to our editorial, "What's Wrong in Jersey," in the Oct. 6 issue. To many it will be gratifying to be assured by Mr. Case that Commissioner Bryant is doing all he can to complete the organization of the License Bureau. We, too, believe he is doing all he can. We believed it when we published the editorial referred to, and we further believe that the commissioner has tried to do so much that he actually got little done. The commissioner means well, but he is trying to please too many people and the old fable has it about right on the probable success of that endeavor.

We also think it was well for the commissioner to endeavor to secure the services of "the third appointee," which Mr. Case mentions. This man has successfully conducted his present plant for many years and has had experience on the engineers' license board in his own city that should be of value to the commissioner's department. But the law states that the appointees shall be approved by the civil-service commission, and when it would not approve of this one, it must have been because the commission's examiner reported that he did not pass the two examinations given him.

Notwithstanding this, this man might make a better examiner than those who will eventually be approved. But the point is this: Should the enforcement of a law that the engineers of New Jersey have worked for twenty-seven years to get enacted be allowed to drag along for so many months without better reasons than those put forth? We do not think so. There are now good reasons to believe that the necessary appointments will soon be made and that the bureau will begin its work. This is gratifying.

* * *

Specialization in the Power Plant

Few industrial workers today need to be urged to specialize in their duties. The subdivision of labor in large organizations forces many a man endowed with intiative and imagination to confine his working activities to pretty narrow areas. The power plant meets this problem in the organization of its operating staff—how should the men be classified and their responsibilities assigned? With the close figuring practiced in many big installations it is obvious that there can be no such overlapping of duties as is often found in smaller plants; little connection appears between the activities of the water tenders and those of the switchboard operators so far as the relations of the men are concerned; and the extent of supervision provided leaves little opportunity for mutual intercourse.

The exact opposite prevails in the small installation. The engineer may not shovel coal unless in a great emergency, but the variety of his duties and the interest of the boiler-room force in what goes on on the other side of the fire wall are usually much greater; a sort of interchange goes on from one end of the station to the other, and where this is encouraged by the chief without letting it get so far along as to undermine individual responsibility, it makes for highly efficient service. Generally speaking, the smaller stations call for men of the all-around type; but this by no means indicates that their work must necessarily be superficial. Which of these two diametrically opposed methods of operation is the better?

It is easy to answer that the big plant is the place for the specialist and the small one the place for the all-around man, but that is not sufficiently conclusive to be helpful. The small installation cannot afford an elaborate organization anyway, and to the great credit of the men behind the throttle and the shovel in hundreds of such plants it must be acknowledged by the most ardent advocates of extreme specialization that a great organization does not in itself guarantee the highest operating efficiency. The personal equation is the chief factor in successful service everywhere. The real answer is that a combination of the two points of view is needed to secure the best results, a combination that is unquestionably already responsible in many medium-sized installations for the excellent operating records obtained in them.

All-around individual service will continue to be demanded in the small station, and if thorough work, team play and absorbing interest in every branch of operation are cultivated little more can be asked. The greatest danger of the small plant is that the multiplicity of tasks falling upon its limited staff will tempt men often overburdened to superficial performance. Fortunately, a genuine professional pride exists to safeguard the operating man against this, and within the limits of its possibilities, the small station is doing remarkably well in innumerable cases. Its operating staff may not be known as specialists in national engineering circles, but by taking an interest in what the big plants are doing, by comparing notes with other fellows in the same range of outputs, and by doing each little job as well as it could be done by a large organization, real gains will be recorded.

As for the large station, its specialists may delve deep into the secrets of heat-unit losses, the proper adaptation of equipment to loads, the articulation of main units and auxiliaries, etc., but they cannot escape the necessity of comprehensive administration. The more that the men in every such station department can learn about the workings of other branches of plant service, the better. Let the man whose time is occupied with the analysis of coal and ashes, water and lubricants, gain at least a general knowledge of how the various generating units are handled on the floor. Let the switchboard operater familiarize himself with the path of the fuel from the barge to the grate and let the boiler room shifts be given an indicating kilowatt meter, showing the instantaneous output of the plant wherever possible. The installation of such instruments in the last year or so is one of the greatest steps ever taken toward coalescing the interests of the men on the steam and the electrical ends of station service. No doubt, responsibilities must be pretty rigorously defined and observed in plants of immense size, but no printed set of rules is ever likely to cover the necessary procedure in every possible operating emergency, and the broader the interest, willingness to help outside exact limits and appreciation of the other man's point of view, the better. It is a question if an excessively restricted organization can be as effective in power-plant service as in the past has been believed, and anything that can be done to encourage men to look over the edges of their own little grooves and to see where all the different channels of service lead is to be commended.

⁂

Shall Railroads Inspect Their Own Boilers?

One of the points at issue between the Committee on Uniform Boiler Specifications of the American Society of Mechanical Engineers and the railways is whether the legislation which the committee proposes for universal adoption shall accept the inspection of boilers used by the railway companies by their own inspectors in lieu of by state inspectors.

In Massachusetts and the states and cities based on the Massachusetts law, the inspectors of companies doing boiler insurance must be approved by the state authorities, and when so approved become pseudo state officials, although paid by the insurance companies. They report the results of their inspections to the state department as well as to their own companies and no other inspection is required.

The proposed legislation contemplates, we believe, the inspection by the state of all boilers used which do not come under the jurisdiction of the Interstate Commerce Commission. In this way all railway boilers will be inspected either by the federal or the state authorities, and this applies to locomotive-crane, pile-driver, hoisting and stationary boilers as well as to those of regular locomotives.

Each locomotive boiler has to be inspected at frequent intervals to insure uninterrupted service as well as freedom from accidents. The railway companies employ a corps of men to keep up these inspections, and the Interstate Commerce Commission accepts their inspection of boilers used in interstate service when it is unable, by reason of the army of inspectors which it would otherwise be obliged to maintain, to have them inspected by its own men. The contention of the railroads is that the state should similarly accept the inspection of the railroad boilers by its own employees.

There is a principle involved here quite different from that in the case of the insurance company inspector. The boilers would be inspected by men who depended for favor, advancement, and even for continued employment upon the owners of the boilers they were inspecting.

The managements of some railroads would be broad enough to encourage these inspectors to expose rather than to gloss over violations of and departures from the orders of the Board of Boiler Rules. Other companies than railroads, however, would be as well entitled to have their inspection done by their own employees.

An industry with a large number of boilers could simply appoint an employee as the official boiler inspector for the company and his status with regard to holding them to a strict compliance with the law would be quite different from that of a state or insurance inspector, who could insist on what he thought necessary without prejudice to his position. If a company with a large number of boilers could do this, one with a small number could appoint its engineer or chief fireman its official inspector and the law would become a farce.

Self-inspection may do as applied to locomotives, but danger attends its too broad application.

⁂

Municipal Safety-Firstism

Portland, Ore., has stolen a march on all the other cities in the United States. It has the first Safety-First Commission, the chairman of which, Harry P. Coffin, was recently appointed by Mayor Albee. For a new thing it starts off wonderfully full grown and complete, for it has departmental organization and the selection of department heads shows discrimination. The chief of police heads the Department of Safety; a general superintendent of a railroad is head of the Department of Railroad Transportation; the chief claim agent of the local railway, light and power company has charge of the Department of Electrical Transportation; the superintendent of schools, the Department of Schools—besides which there are the Department of Industries, Department of Fire Prevention, and a Traffic Department, over which the chairman of the Commission will preside.

Details regarding the plans of campaign in the various departments, and also the posters and warning signs that will be posted, show a determination to make the Safety-First movement count in that vicinity. If it accomplishes one thing—and that is expressed in one of the slogans—it will be worth all the effort—"Stop, look, think!" These three admonitions carried out in the order indicated would avert a very large proportion of the accidents we read about every day. In fact, it is claimed that 98 per cent. of the accidents are preventable.

One thing we are sorry they omitted in the organization proposed for Portland is a Department of Boilers. We earnestly commend it to Mayor Albee and Commissioner Coffin as worth inclusion in the splendid system they have. It is a good token, however, when a city interests itself in the safety of its inhabitants, and we believe that if Portland has not already got engineers' license and boiler-inspection ordinances, the local engineers would find the present administration a good one to help them to get such laws.

⁂

It would be "bully" if someone would discover some way to reduce boiler performances under different conditions to exact figures comparable without conjecture.

⁂

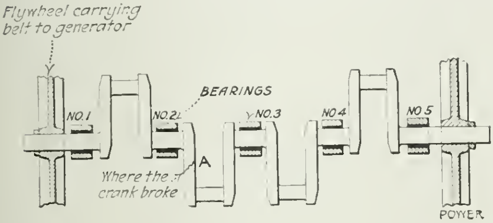
The Edison Electric Illuminating Co., of Boston, has bought from the Metropolitan Water & Sewerage Board of Massachusetts the total output of a hydro-electric plant, to be built by the state in connection with the Boston water-works system. The output of about three million kilowatt-hours annually will be furnished primarily from the discharge from a reservoir in the system. On the other hand the Edison company, together with the Boston Elevated Railways Co., will supply current to operate the motor-driven pumps in the new Boston high-pressure pumping station. Sort of a pass-it-along affair.

Correspondence

What Caused the Break?

We have 2 four-cylinder engines of the four-stroke-cycle type running on producer gas, one is a 115-hp., connected by a clutch to a 40-ton ammonia compressor, and the other, a 100-hp., is similarly connected to a 30-ton ammonia compressor and also belted to a 30-kw. generator. I came on watch at 7 p.m., and at 7:30, the crankshaft on the 100-hp. engine broke.

There was a 30-ampere load on the machine at the time. Both engines were running on the ice machines, which had a back pressure of 16 lb. and a head pressure of 180 lb. with the expansion valve almost wide open. Suddenly the belt that runs the generator almost jumped off and there was an unusual noise in the crank case. I shut the engine down and found that the crankshaft was broken. When we removed the shaft, which is 6 in. in diameter, we found nearly all the babbitt wiped out of bearings No. 1 and 3, but the other three were in good condition. I should like to have opinions expressed as to what caused the crankshaft to break.



Types of Crankshaft

E. M. Merrill.

Chicago, Ill.

⁂

Motor-Trouble Diagnosis

Some years ago I was hurriedly sent to a machine shop to find out why an electric motor, the main drive of the shop, would not run.

Upon closing the main switch the pilot lamp burned brightly, so I proceeded to bring the starting-box lever over. As the field circuit was made, the lamp dimmed, going entirely out when the starting resistance had been cut out of the armature circuit. This performance invited a ready deduction, which the following will serve to demonstrate:

Referring to the diagram, let A represent one of the leads which has parted in the manhole, the ends being submerged as shown: C the pilot lamp; D the motor field and E the armature. Assuming a resistance of 20 ohms through the fault, and with the starting-box lever in the off position, only the fault and the lamp would be in the circuit. The lamp, being of the ordinary carbon type (110-volt, 16-cp.), would require about one-half an ampere, thereby, in accordance with Ohm's law, causing a 10-volt drop at the fault and giving at the pilot-lamp terminals $115 - 10 = 105$ volts decrease from the normal voltage of the lamp of 5 volts, which would not be very noticeable in daylight.

Neglecting the paralleling of the motor field with the lamp, their joint conductivity being relatively negligible when the motor armature is paralleled with them, we have, assuming an armature resistance of 0.25 ohm, $20 + 0.25 = 20.25$ ohms as a total resistance. This resistance, assuming a line voltage of 115 volts, would allow a current of $115 \div 20.25 = 5.679$ amperes.

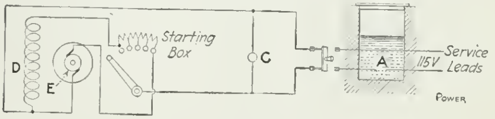


Diagram Showing Location of Fault

This would cause a drop in voltage at the fault of 113.58 volts, which would leave of the 115 volts only $115 - 113.58 = 1.42$ volts, at the motor terminals.

Amos J. Carr.

Fort McKinley, Maine.

⁂

Poor Firemen

Someone of Power's editorial writers must be very unfortunate in the company he keeps, or he would not have written that editorial "Attention of Firemen" (Sept. 15). The statement that, "Seldom is any disposition shown by the men in the fireroom to study to improve their condition," is rather startling. It would be interesting to learn how many of the engineers who read Power once handled the coal scoop. Probably the percentage would be quite large. And they have not risen without some "study to improve their condition."

There comes to my mind a man working in a fireroom twenty-five miles from Boston. For the last three winters he has attended an evening technical school in that city, making the trip three or four nights a week. Other evenings, Sundays and holidays were taken up by study. This may be an extreme case. Not many men in any walk of life have "sand" enough for that.

Among my acquaintances in the fireroom are many men who little resemble the picture drawn in the editorial. If the writer of that editorial will come with me, I will take him into firerooms all day long; and in all of them, we will find men who not only can talk about evaporation, but who actually watch the log sheet with interest. In not a few, we will talk with firemen who can converse intelligently about the relation of draft to thickness of fire, and the treatment best for certain grades of coal. And unless said writer is expert in use of CO_2 apparatus and interpretation of the records, I would suggest that he refresh up a bit before we start, for we shall meet men who know a thing or two about combustion.

Occasionally, one finds a plant where the firemen "know little and care less." In such cases, the most likely place to look for the cause of this trouble is in the vicinity of the chief engineer's chair.

Speaking of "Filling up the furnace clear to the door," brings to mind a plant of which I once took charge. That was the plan of firing there. For a few days I watched those men stand two at a furnace and heave coal until it poured back out of the doors. When I stepped in and changed things, there was a tickled bunch of firemen in that plant. They had been doing as they did because they had been made to do so. "It was killing us," they told me. All were interested in the resulting economy.

Here are some of the things that a chief engineer may do to help the firemen. In the advertising pages of Power he will find instructive illustrations of apparatus around the plant. Get a lot of picture frames and mount each in a separate frame, adding what explanation (typewritten or printed) seems necessary. If Power does not supply the required help, a catalog probably will. If not, a blueprint may be made.

Go out into the fireroom and show the men how you want the work done. This will interest and encourage them.

Have a standard wherever you can—a standard water level, a standard method of cleaning fires, a standard thickness of fire, a standard method of coaling, etc. Things will run smoother in the plant if you do. And hold the men to these standards—not so rigidly as to be foolish, but with wise firmness. If a man thinks he has an improvement, encourage him to come and talk it over. If it looks good, let him try it; and watch the trial. If it does not, try to show him your reason for refusal.

Lastly, remember that they belong to the same division of the animal kingdom as yourself.

William E. Dixon.

Cambridge, Mass.

⁂

Reversing a Cable Drum

We often want to pay out rope on a second-motion friction-clutch haulage system having nonreversing engines. To put on reversing eccentrics and links would be quite expensive and as the engine has to run at a high rate of speed, they would be objectionable on that score also. We put on the device shown and can now pay out rope at will without reversing the engine.

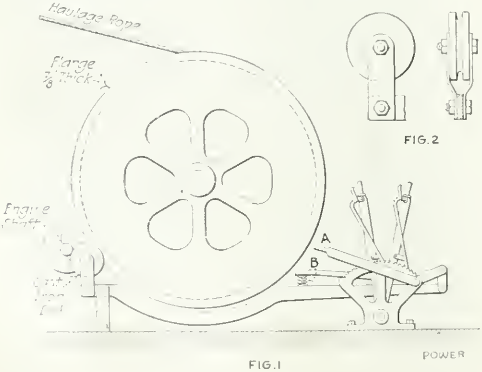


FIG. 1

FIG. 2

Friction Disk between Drum and Engine Shaft

Fig. 1 shows the drum, the cast-iron disk, and the control levers. Fig. 2 is the cast-iron disk.

By releasing the brake and clutch and pulling up on lever *A*, the disk is pressed against the engine shaft and the flange of the drum (in the groove shown in Fig. 2), and causes the drum to rotate in the unwinding direction. *B* is a coil spring which holds the lever up and keeps the disk from rubbing the engine shaft or flange when not in use.

J. J. Piper.

Colorado Springs, Colo.

⁂

Improving a Pump Stuffing-Box

On a large pump the stuffing-box was so shallow that it would hold but two rings of packing at a time. As they had to be kept tight, they scored the rods. While making general repairs the stuffing-box was turned out $\frac{3}{16}$ in. larger in diameter. A cast cup was then made to fit inside, and 3 in. longer, which besides reducing the size of packing required, made additional room for two more rings. A gasket was then put in the bottom of the stuffing-box and the cup placed in position and drawn up tight with nuts on the gland studs. The gland was then turned down and the job was complete and satisfactory.

Louis B. Carl.

Marshfield, Wis.

⁂

Sizes of Motors Driving Centrifugal Pumps

We have just read the article by E. M. Marshall on "Sizes of Motors Driving Centrifugal Pumps," which appeared in the Sept. 15 issue. Attention is called to trouble which occurs owing to disregard of pipe friction when figuring total head. The more publicity given to this matter the better, but it seems that the author has criticized the pump manufacturer in too general terms, particularly in the following statement.

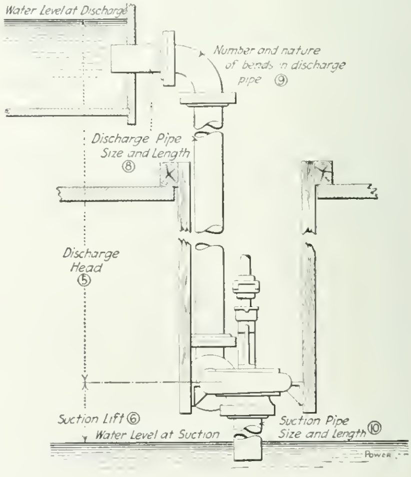

Water Level at Discharge
Number and nature of bends in discharge pipe ⑨
Discharge Pipe Size and Length ⑧
Discharge Head ⑤
Suction Lift ⑥
Water Level at Suction
Suction Pipe Size and Length ⑩
Power

Fig. 1. Measurements for Vertical Pump

"Manufacturers sell pumps to be connected to certain types of motors and when electrical troubles come up, they are glad to refer them to the maker of the motor, but are little interested in securing and tabulating for future use the nature of the trouble and the remedy."

The pump manufacturer is often called upon to assume the account for both the pump and the motor, and we believe that the majority of pump manufacturers pay prompt attention to complaints in regard to motors driving their apparatus and that the motor manufacturers in turn, when such complaints are put up to them, are only too glad to investigate.

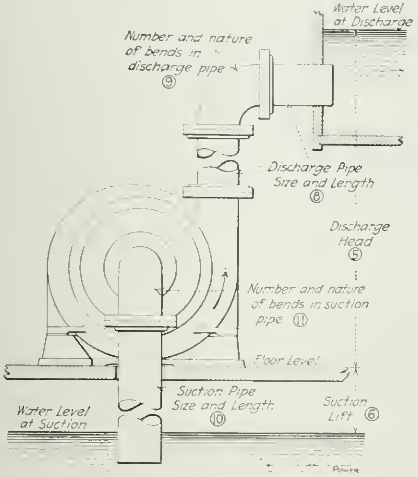

Water Level at Discharge
Number and nature of bends in discharge pipe ⑨
Discharge Pipe Size and Length ⑧
Discharge Head ⑤
Number and nature of bends in suction pipe ⑪
Floor Level
Suction Pipe Size and Length ⑩
Suction Lift ⑥
Water Level at Suction
Power

Fig. 2. Measurements for Horizontal Pump

The various motor companies do a large resale business with pump builders and naturally have to give good service. One particular reason why the motor builders like to sell their apparatus to the pump builders is that the latter usually exert great care in seeing that the proper motor is applied for the conditions under which the pump is to operate.

It is our practice to have the purchaser fill out the "Centrifugal Pump Data Sheet," herewith shown, before we start actual construction, provided the pump is to be directly connected to an electric motor. This enables us to carefully check the total head against which the pump is to operate.

CENTRIFUGAL PUMP DATA SHEET
Shop Order No..... ... ...

1. Capacity of pump........ U. S. gallons per minute.
2. Character of fluid... salt, fresh, clean or dirty......
3. Temperature of the liquid.... °F. Specific gravity......
4. If solid matter is contained, state size and character of largest pieces ....
5. Discharge head... .ft. (This is the vertical distance from the floor level of the pump to the point at which the water is discharged.)
6. Suction lift... .. . .ft (This is the vertical distance from the floor level of the pump down to the level of water in pit from which it is pumped.) (See No. 7.)
7. Suction head .. . .ft. (Sometimes the pump is placed so that the water will flow to it and in that case the pressure at the inlet to the pump must be given. Question No. 6 may then be omitted.)
8. Discharge pipe diameter . . .... length.... ....
9. Number of bends in discharge pipe .. .. State whether elbows are 45 or 90 degrees . ... . and of long or short radius . . . .
10. Suction pipe diameter . length ..
11. Number of turns in suction pipe State whether elbows are 45 or 90 degrees . and if long or short radius .

Signed ....
Date.. .... Address ....

Mr. Marshall refers particularly to the greater power required due to increase of head caused by pipe friction. We would point out that the question of speed required for this greater head is likewise important in the case of a centrifugal pump.

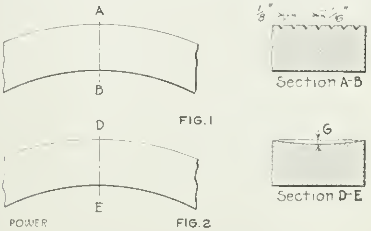
E. C. Wayne,
Goulds Mfg. Co.

Seneca Falls, N. Y.

Machining Piston Rings

Sometimes new piston rings in steam and gas engines leak, due to a poor fit in the cylinder, and it takes a long time for them to wear to a tight joint, even if both rings and cylinder are ground to a good fit when cold.

Figs. 1 and 2 show two methods of machining the faces of rings which will cause them to adapt themselves to the cylinder bore in a very short time. Rings turned with V-shaped grooves about $\frac{1}{16}$ in. wide, spaced about $\frac{1}{8}$ in. apart, as in Fig. 1, or made slightly concave, as at *G*, Fig. 2, will soon wear down to a good running fit.



Two Forms Suggested

M. E. Griffin.

Franklin, Penn.

What Is Wrong in Jersey?

In reply to an editorial appearing in the Oct. 6 issue, I wish to rectify some of the statements made regarding the organization of the Engineers and Boiler Operators' License Bureau in New Jersey.

Having been closely connected with this matter while it was before the state legislature, and since that time, particularly during the past three months, I wish to assure the engineers interested that the Commissioner of Labor has made all reasonable effort to perfect the organization of this bureau. There is no question of truth regarding his inability to do so during the first year of the existence of this law, and the matter was taken up by him actively immediately following the appropriation made by the last legislature for this purpose.

The conditions of the law imposed a situation which has been found difficult to meet satisfactorily. These are, that the salary offered by the state for this work was no inducement to the class of men who would be desired by the department for the work, thereby eliminating most qualified men from even a desire to enter the field, and as the law also required an experience of ten years actually in charge of a steam plant of 250 hp., or more, develop oped another process of elimination, so that in the final determination there have been very few from which to choose, and, in addition to these difficulties, the Civil Service Commission has seen fit to adopt a rigid examination before issuing a certificate to anyone whom the Commissioner of Labor may have selected: and if, as you express it, there is a deep feeling of dissatisfaction among the engineers, it cannot be otherwise than their lack of knowledge of the conditions which have operated to prevent the completion of this Board, and any charge that the Commissioner of Labor has played politics is without just foundation.

The facts are that one of the earlier appointees personally eliminated himself from the Board by withdrawing his name from the appointment. As the third appointee has always been considered one of the best engineers in the state, was so considered by the department, due to his known experience and business ability, it was considered but justice to him, and to the best interest of the department that extra effort be made to secure his acceptance by the Civil Service Commission, and it has only been during the present week that this matter has been finally settled. I wish to assure all interested that no attempt has been made by the Commissioner or anyone else to railroad, as you term it, anyone either into or out of office, and further that only the greatest care and investigation have been used by this department in an endeavor to appoint competent men.

I hope all interested will bear patiently with this department until it can be finally organized and accept the work of the Board as the final determination of the honest effort which has been made to make the department a working success.

A. L. Case.

Trenton, N. J.

⁂

Operating Engineer as a Purchasing Agent

The editorial with the above title in the issue of Sept. 22 is extremely interesting, and the subject matter of vital importance. Correct buying involves a multitude of economic and engineering considerations, and the one "best buy" for any specific condition is not easily found. Many purchasing agents would do well to acquire some engineering knowledge, and it seems equally true that most operating engineers sadly need grounding in the fundamentals of buying.

It is pointed out that the man higher up will listen to the neat-appearing salesman with forceful arguments much more readily than to the operating engineer in greasy overalls and a mediocre "line of talk." True, but the overalls need not be any hindrance. A man in a shipshape rig, with a clean shave, a clear, steady eye and a carefully garnered supply of specific detailed information can easily convince the purchasing agent of just what his plant requires long before the salesman has registered at the local hotel.

In visiting the man behind "the door marked private," do not forget your economics. It is a poor argument to dwell on the fact that the equipment you are recommending will pay for itself in two years or so. The same money, if invested in another department, might double itself in half the time. The man you are talking to is there to invest to the best possible advantage, and you must get his viewpoint to succeed. Have figures all worked out, and do not forget such fundamentals as interest on the investment, depreciation and all burden charges. In fact, try and imagine yourself in the owner's shoes, try and look next Saturday's payroll between the eyes, the lean sales for last month, the show-me-or-get-out board of directors, and then, ask yourself if the proposed expenditure is absolutely necessary.

Before making the visit to the front office, put your proposition down in writing. You are going to ask another man to spend his money. It is a serious business. Make sure in your own mind that you know what you want to say and how to say it. Arrange your aruguments in logical sequence; talk dollars and cents first, and technical "reasons why" only if necessary, and not to display your vast engineering knowledge. When the boss thinks in terms of the balance at the bank, it is well to forget the back pressure resulting from B.t.u. lingering somewhere between the exhaust ports, and the condenser. Observing all the foregoing suggestions, take up again the matter of economy, and see if you cannot save your salary by installing the right apparatus for reclaiming unnecessary waste.

E. Hurst.

Montour Falls, N. Y.

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Duplex Pumps Not Good for Jet Condensers

The question is often asked, "Why is the duplex pump not more frequently used in connection with jet-condensing apparatus?" It is frequently used as a circulating pump with surface or barometric condensers, but with jet types, where it removes the air as well as the condensing water, it cannot be used with any degree of satisfaction. This is because the steam valves are operated from the opposite side, consequently if one side should become air-bound, the work of this cylinder being less, it would operate too quickly and by so doing would shift the valve of the other cylinder in the same manner, causing a very intermittent action. This, however, only occurs when there is a considerable quantity of air present.

John F. Hurst.

Louisville, Ky.

⁂

Patching Boilers

I have just noticed the letter by Dale S. Miles on p. 355, Sept. 8, under the above caption. It is, of course, possible to derive a rule for the efficiency of a diagonal joint that will hold for extreme cases as well as for those encountered in practice, but such a rule involves the use of trigonometry and is therefore not as convenient as that given by Mr. Mason in his book, "The Arithmetic of the Steam Boiler."

Any slight inaccuracy due to the use of the rule in question, for practical boiler work, will be found to be less than that of some other factors, such as measurement, calculation and workmanship. Hence the slight difference in results by using this rule may be overlooked.

It is a fact that many practical rules in engineering do not give absolutely correct results or do not hold in extreme cases, yet these rules should not be condemned on that account.

W. G. Hawley.

Scranton, Penn.

Inquiries of General Interest

Placing Globe Valve on Feed Pipe—When a globe valve is used on a boiler feed pipe on which side of the valve disk should the inlet be?

E. J. M.

The inlet should be under the disk of the valve, i.e., tending to open the valve, otherwise should the disk become detached, it would obstruct the passage of feed water to the boiler by acting like a reversed check valve.

Standard Cubic Foot of Gas—What is meant by a standard cubic foot of gas?

G. L. C.

A cubic foot of gas taken under standard conditions of temperature and pressure, i.e., at a pressure of 29.92 in. of mercury and 32 deg. F. or the equivalent, viz.: at a pressure of 30 in. of mercury and 62 deg. F., these pressures at the corresponding temperatures being equivalent to 14.7 lb. per square inch.

Flash, Burning and Chill Points of Oil—How are the flash, burning and chill points of an oil determined?

L. F.

The flash point is found by placing the bulb of a thermometer in a porcelain dish filled with the oil to be tested, then heating the oil over a Bunsen burner and noting the temperature at which a flash is obtained from passing a lighted taper over the surface of the oil. The "burning point" is found by carrying the heating to a temperature at which the flash causes the oil to burn. The "chill point" is found by first chilling a small quantity of the oil in a test tube surrounded by a freezing mixture until the oil congeals, then stirring the congealed oil with a thermometer and noting the temperature when the oil has warmed sufficiently to be flowed from one end of the test tube to the other.

Stayed Area of Boiler Head—What is the rule for finding the area of that portion of a return-tubular boiler head which should be stayed?

F. W. A.

The area which requires staying is a circular segment 3 in. inside of the shell and 2 in. from the tubes. The formula for finding the area of such a segment is:

$$A = \frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H} - 0.608}$$

in which

A = Area of segment in square inches;
H = Distance in inches from the tubes to the top of the shell, minus 5 in.;
R = Radius of boiler in inches, minus 3 in.

Mean Effective Pressure with ¼ Cutoff—With initial pressure at 100-lb. gage, cutoff at ¼ of the stroke, cylinder clearance 5 per cent., and average back pressure 4 lb. above atmosphere, what mean effective pressure would be realized?

J. G. W.

The formula generally employed for determining the average forward pressure per pound of absolute initial pressure is that for isothermal expansion, viz:

$$P_m = (1 + \log_e R)\,(f + c) - c,$$

in which

P_m = Mean forward pressure per pound of initial absolute pressure;
$\log_c R$ = Hyperbolic logarithm of the ratio of expansion;
f = Per cent. of stroke complete at cutoff;
c = Per cent. of clearance.

Multiplying the mean forward pressure per pound of initial absolute by the actual initial gives the average forward pressure, and deducting the average back pressure gives the m.e.p.

Instead of computing the average forward pressure per pound it is usually taken from tables such as those in Low's "Steam Engine Indicator," pages 115 and 116. For ¼ cutoff and 5 per cent. clearance the tables give $P_m = 0.6258$. The initial pressure being 100 + 14.7 = 114.7 lb. absolute, the average forward pressure would be

$$0.6258 \times 114.7 = 71.78 \text{ lb. absolute,}$$

and the average back pressure being

$$4 + 14.7 = 18.7 \text{ lb. absolute,}$$

then

$$71.78 - 18.7 = 53.08 \text{ lb m.e.p.}$$

Delivery per Revolution of a Duplex Pump—Allowing 5 per cent. slippage, how many gallons of water would be delivered per revolution by a duplex pump having water cylinders 14 in. in diameter by 16 in. stroke and piston rods 2½ in. in diameter?

F. G.

Each piston 14 in. in diameter would have an area of

$$14 \times 14 \times 0.7854 = 153.94 \text{ sq.in.,}$$

and for one stroke in the head end of each cylinder the piston displacement would be

$$153.94 \times 16 = 2463.04 \text{ cu.in.}$$

With piston rods 2½ in. in diameter the cross-sectional area of each rod would be

$$2\tfrac{1}{2} \times 2\tfrac{1}{2} \times 0.7854 = 4.91 \text{ sq.in.,}$$

and the net area of the rod side of each piston would be

$$153.94 - 4.91 = 149.03 \text{ sq.in.,}$$

hence for one stroke in the rod end of each cylinder the piston displacement would be

$$149.03 \times 16 = 2384.48 \text{ cu.in.}$$

Therefore the piston displacement per revolution in one cylinder would be

$$2463.04 + 2384.48 = 4847.52 \text{ cu.in.,}$$

and for both cylinders it would be twice as much, i.e., 9695.04 cu.in., or a total piston displacement per revolution of

$$\frac{9695.04}{231} = 41.97 \text{ gal. per rev.}$$

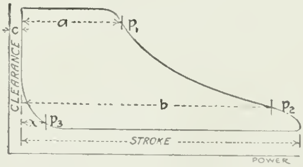
With 5 per cent. slippage there would be an actual delivery of $41.97 \times (1 - 0.05) = 39.87$ gal. per rev.

Steam Consumption from Indicator Diagram—What is the formula for computing the steam consumption of a simple engine from the indicator diagram?

W. S. K.

The formula is:

$$Q = \frac{13{,}750}{\text{m.e.p.}}\left[(F + c)\,W_f - (x + c)\,W_x\right]$$



STEAM CONSUMPTION FROM INDICATOR DIAGRAM

where

c = Clearance in fraction of the stroke;
F = Fraction of stroke completed at a point chosen on the expansion line (which point should be like p_1, near the point of cutoff, where a would represent the fraction of stroke; or p_2 near the point of release, where b would represent the fraction of stroke);
x = Fraction of stroke uncompleted at a point like p_3 chosen on the compression line;
W_f = Weight per cu.ft. of steam at pressure shown on the expansion line at the fraction a or b of the stroke;
W_x = Weight per cu.ft. of steam at the pressure of compression shown on the compression line at the uncompleted fraction of stroke x;
Q = Steam accounted for per hp. per hour.

The result will always be less than the usual amount of steam supplied to the engine, because a considerable proportion of such steam is condensed upon its entrance to the cylinder, and is not reëvaporated until after the valve opens for exhaust, so that it does not show at all on the diagram

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power Plant Design--II

Power for Driving Machinery

After having made a general study of the conditions to be met, and having prepared an outline of the methods to be followed, as given in the previous article, the next step is to find the capacity of engine and generator for driving the machinery of the plant. In the machine shop there is a total of 250 hp. to be supplied to the machines, when all are running at one time. Of this, 150 hp. is to be furnished by two motors belted to the line shafting. In cases of this kind it is customary to assume that the friction of the main shafting and various countershafts makes up about 30 per cent. of the total load. Therefore, in the present case,

$$150 \div 0.7 = 214\ hp.$$

must be delivered to the line shafting by the two motors. Assuming an efficiency of 90 per cent. for these at full load

$$214 \div 0.9 = 238\ hp.$$

of electrical energy must be delivered to these motors.

In addition to the above, 100 hp. of mechanical energy is to be delivered to individual machines by direct-connected motors. The efficiency of small motors working under these conditions will not average much more than 60 per cent., so that

$$100 \div 0.6 = 167\ hp.$$

must be provided for this part of the work. This makes a total of

$$238 + 167 = 405\ hp.$$

of electrical energy to be supplied to the building when all of the machinery is in operation.

Taking up the other buildings to which power is to be supplied in like manner, the following is obtained: In the foundry, 15 hp. delivered by line shafting calls for

$$\frac{15}{0.7 \times 0.9} = 24\ hp.$$

and 15 hp. by direct-driven motor calls for

$$\frac{15}{0.6} = 25\ hp.$$

making a total of

$$24 + 25 = 49\ hp.$$

of electrical energy to be delivered to the building.

In the forge shop 15 hp. delivered by line shafting calls for

$$\frac{15}{0.7 \times 0.9} = 24\ hp.$$

and 10 hp. for direct-drive motors, requires

$$\frac{10}{0.6} = 17\ hp$$

making a total of

$$24 + 17 = 41\ hp.$$

for the building.

In the pattern shop 20 hp. delivered by line shafting calls for

$$\frac{20}{0.7 \times 0.9} = 32\ hp.$$

In the carpenter shop 5 hp. delivered by line shafting calls for

$$\frac{5}{0.7 \times 0.8} = 9\ hp.$$

The total power required for the plant with all machinery in operation (exclusive of ventilating fans and electric pumps) is

$$405 + 49 + 41 + 32 + 9 = 536\ hp.$$

Under actual working conditions only a part of the machines will be running at one time, and it is usually considered ample to provide 75 per cent. of the power as computed above, which in the present case, is

$$536 \times 0.75 = 402\ hp.$$

To determine the total power load it will be necessary to estimate the power required for operating the various ventilating fans and for pumping the water from the river to the reservoir in the yard. These computations will be made accurately later on, when this part of the equipment is designed, but for present purposes an approximation of the power required for this work will be sufficiently accurate. Four changes of air per hour in the machine shop, pattern shop and toolroom, and six changes in offices and drafting room will call for the delivery of approximately 6,340,000 cu.ft. of air per hour by the fans, while the conditions of ventilation called for in the foundry and forge shop will require the moving of about 1,600,000 cu.ft. more, or a total of

$$\frac{6,340,000 + 1,600,000}{60} = 132,333\ cu.ft.\ per\ min.$$

Under the conditions found in this class of work it will require approximately 1 hp. delivered at the fans for each 1700 cu.ft. of air moved per min., or in the present case

$$132,333 \div 1700 = 77.8 = 78\ hp.$$

Assuming motor efficiencies of 85 per cent. This part of the work will call for

$$78 \div 0.85 = 92\ hp.$$

or for a round number, say 90 hp.

The arrangement proposed in regard to the division of power, and for condensing, is as follows: The main engine is to be of sufficient size to drive the machinery, including ventilating fans and electric pump. It is to be run noncondensing during the winter and the exhaust utilized in the heating system. In the summer, when the exhaust would be wasted, the engine is to be run condensing to secure greater economy in steam consumption. If computations show the exhaust from the power engine to be sufficient for heating purposes, then the condensing apparatus may be used in connection with the lighting engines during the heating season, at which time the lighting requirements will be at a maximum.

If, however, the exhaust from the power engine is not ample for heating purposes, then sufficient exhaust from the lighting engines may be used to make up the deficiency while they are in use.

During the nonheating season, the power engine will be run condensing. As the nonheating and nonlighting seasons practically coincide, the lighting engines will not be used to any extent during the summer, except on cloudy days and to furnish lights at a few special machines. This leaves the condensing apparatus free for independent use by the power engine. There may be a short time in spring and fall when the lighting engines will be used with the heating plant shut down, but with compound engines having a good steam economy, it would hardly be worth while to provide condensing equipment for use during these short periods. The best arrangement would probably be to furnish a condenser of sufficient capacity for the power engine. Then run this engine condensing during such part of the year as the increased economy was found to exceed that due to utilizing exhaust in the heating system. For the remainder of the year, the power engine would be run noncondensing, and the condenser would be available for one or more of the lighting engines whenever it was found advisable to use it.

As the weight of condensing water required is from 30 to 35 times that of the steam condensed, it is evident that a supply computed on this basis will be ample for all purposes at any time of the year. For example, during the winter, with the exhaust used in the heating system and the condensation returned to the boilers, there will be a comparatively small amount of "make-up" water required, and if part, or even all, of the lighting engines are run condensing, the water requirements will probably not exceed those for which the plant is regularly designed. If, however, a larger quantity should be required temporarily, the surplus stored in the reservoir may be drawn upon to make up the deficiency.

In the summer, with the power engine running condensing, the maximum quantity of water will be required, but at this time the boilers may be fed from the cooling water after it has been used in the condenser, so that no extra amount will be required for this purpose. It will, therefore, be seen from the above that a water-supply based on that necessary for condensing in the summer time will be ample for all purposes.

SIZE OF MAIN ENGINE.

The electrical energy to be delivered to the motors in the different buildings was found to be

$$102 + 90 = 192\ hp.$$

Taking the transmission or line loss as 5 per cent., the efficiencies of generator and engine as 90 per cent. each, the indicated horsepower of engine must be

$$\frac{192}{0.95 \times 0.9 \times 0.9} = 640$$

Before computing the water required for condensing we must assume the power required for pumping this amount from the river to the reservoir, and make a trial computation. Taking this as 30 i.hp. at the main engine, it will call for a total of

$$640 + 30 = 670\ i.hp.$$

A compound condensing engine of the moderate-speed four-valve type will require approximately 18 lb. of steam per indicated horsepower per hour, or

$$18 \times 35 = 630\ lb.$$

of condensing water. For the above engine this amounts to

$$\frac{670 \times 630}{60} = 7035\ lb.\ per\ min.$$

The theoretical power required for pumping water is given by the formula:

$$horsepower = \frac{W \times H}{33,000}$$

in which W equals the weight of water pumped per minute and H the height to which it is raised, including the friction head. Applying this to the present case, assuming the friction head to amount to 5 ft., gives

$$horsepower = \frac{7035 \times (50 + 5)}{33,000} = 11.7$$

or practically 12 hp. Assuming a line loss of 5 per cent., pump efficiency 65 per cent., motor efficiency 85 per cent., and generator and engine efficiencies of 90 per cent. each, as before, the indicated horsepower to be provided in the main engine for this purpose will be

$$\frac{12}{0.95 \times 0.65 \times 0.85 \times 0.9 \times 0.9} = 28$$

which comes within the limit assumed.

Having found the required power of the engine, the next step is to decide upon the type and general dimensions. As it operates under practically uniform conditions the year around, and is of large power, the steam economy is important. Taking everything into consideration without going too much into detail, it would seem that a cross-compound engine of the medium-speed four-valve type would be well adapted to the present case. Ample room for an engine of this type is easily provided, the power house being new, and it may be direct-connected to the generator, which is a mechanical feature of considerable importance. As previously stated, it will be advisable to run noncondensing for a considerable portion of the heating season to utilize the exhaust steam, but the engine should be provided with a condenser for summer use. Engines of this type and power will vary somewhat with the make. The following, taken from the catalog of a standard company of engine builders, gives data for an engine of approximately this power operated noncondensing under a steam pressure of 20 lb.

Diameter high-pressure cylinder, in.	24
Diameter low-pressure cylinder, in.	38
Stroke, in.	[illegible]
R.p.m.	150
Floor space, direct connected type, ft.	21 × 21

For power work where moderate and variable-speed motors are desirable, direct current is required, and in this case a generator furnishing a current of this kind at 250 volts will be used. As

$$670 \times (0.9 \times 0.9) = 543\ hp.$$

of electrical energy are to be delivered by the machines its rating should be

$$\frac{543 \times 746}{1000} = 405\ kw$$

or 450 kw. to be on the safe side. By making the capacity this much larger than called for, it will have no appreciable effect upon the efficiency under normal working conditions, and will allow a certain surplus for additional calls for power or for lighting in the summer, without starting up the regular lighting plant. For example, on cloudy days in the early fall it will probably be necessary to run a part of the lights for an hour or so at night and a good generator should be able to carry 20 to 25 per cent. overload for this length of time without injury or serious loss of efficiency. In the present case, this would give a surplus of

$$(450 \times 1.2) - 450 = 90\ kw.$$

for purposes of this kind.

Operating the engine condensing at the same initial pressure and cutoff, will increase the power approximately the same amount (20%) over that when running noncondensing. Hence, in the summer, there will be approximately 90-kw. capacity available in the main generating set for temporary lighting, should occasion require. The size of engine noted above has a sufficient capacity, above that called for, to drive a 450-kw. generator without overloading.

It is customary, in practice, to increase the power of the main engine or generating set about 10 per cent., to care for any moderate increase in the required power due to the installation of additional machinery. In the present case, this is provided for by using slightly larger machines than called for in order to make use of stock sizes.

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Test for the Carbonizing Effect of Gas-Engine Oil

By C. L. Cook*

Much has been heard of the so-called "noncarbonizing" lubricating oils for gas and gasoline engines. This property is an important one because the collection of carbon around the valves and in the interior of the engine soon interferes not only with its efficiency but with its actual operation. In an endeavor to find some means of measuring this carbonizing effect for the purpose of passing upon various samples of oil, I have developed the following test. It is my opinion that all oils carbonize, that there is no such thing as a noncarbonizing oil, and that there is a practical limit as regards the amount of carbonization under which an oil will be satisfactory and over which it will be unsatisfactory for use in a gas engine.

Carbonizing is caused by the cementing or binding together of small particles of soot, etc., in the interior of the engine by a sticky residue left by the partial distillation of the lubricating oil when it is exposed to the heat of the burning gas. The temperature is not high enough to completely distill it, hence it accumulates, gathering more carbon, and forming an extremely hard shell or crust upon the walls of the cylinder and the valve surfaces. If the lubricating oil contains considerable gum, the engine carbonizes rapidly while if it contains a relatively small amount the engine seems to be able to get rid of it at the start and a crust is formed only after a relatively long period of running.

The following test produces this formation of carbon from a given sample of oil and measures it quantitatively:

Exactly five grams of the oil to be tested are put into a platinum dish, and two cubic centimeters of benzine or petroleum ether are added. If less ether is added combustion may not be complete and experience has shown that more ether is unnecessary; therefore, for uniform results, this measured quantity should be used.

The dish is then placed in a cylindrical inclosure, made of a can about 6 in. in diameter and about a foot high, without a top and having holes punched in the sides at the bottom to cause a slight draft, and with a wire shelf about 4 in. down from the top, so that the dish can be put on it and the ether ignited by passing a flame over the top of the can. When the combustion has been completed, the dish and contents are weighed. At this stage the dish will be found to be coated with soot and to have a certain amount of a sticky residue in the bottom, looking like tar or asphaltum.

Next, the dish is passed over the flame of a bunsen burner until without further ignition or combustion this tarry residue is evaporated to dryness, assuming a flaky graphitic appearance. The dish and its contents should be weighed again and the loss over the previous weight is that of the gum evaporated. This is a measure of the gumming or carbonizing qualities of the oil, and can be expressed as a percentage of the five grams used for the test.

In numerous oils that were tested this percentage of gum-forming ingredients was found to vary from 0.3 to 3 per cent. For gasoline-engine oil, as used in automobile engines, this percentage should not exceed 1 per cent. One oil in particular was tested and it was found that serious carbonizing which occurred at a percentage of 1.4 per cent. stopped when this was lowered to 0.8 per cent by the use of a better compounder or base.

Lighter oils show a lower percentage of gum, whereas heavier oils have a greater percentage of the compounder which is added to give the necessary viscosity. This gum is introduced into the oil, it seems, as impurities of the compounder; hence the percentage will depend upon the amount and the purity of the compounder used. From this it is evident that the purity of the compounder to be used for a heavy oil is of the greatest importance. Estimating the amount of compounder used in a heavy oil, the writer is of the opinion that this percentage of gum-forming ingredients should not exceed 1.5 per cent. for so-called heavy oils.

The test described can be easily made in fifteen minutes. After having used it for over a year along with the usual tests for gravity, flashpoint, viscosity, and in some instances tests for acidity, alkalinity, and breaking down at 400 deg. F., the writer is now in a position to select a suitable oil at the best price and to be able to successfully interpret the almost unexplainable "kicks" which came from reliable sources and which at first seemed imaginary.

It is to be observed that this test is an arbitrary one, and is not exactly analogous to what happens in the engine cylinder; the gum as measured may or may not be a true measure of the amount deposited in the engine cylinder. If, however, the same conditions are observed in all tests made, the method becomes available for selecting a desirable oil.

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*Chemist, Board of Public Works, San Francisco.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

More power to George Chandler, and all engineers like him! Over 50 years he's been a stationary engineer, 17 of which he was chief engineer with the Bryant Paper Co., Kalamazoo, Mich. Now, at 74, he has voluntarily retired and the company, in recognition of his long service and loyalty, will continue to pay him his full salary. And bully for the company, too. Both boss and chief may well be proud of themselves.

* * *

"College doesn't make fools, it merely develops them," said "Old Gorgon Graham," in his letters. So, if you meet a college feller who you believe is a fool, remember he had a big start in the fool business long before he ever entered college.

* * *

Out in Portland, Ore., they have a Safety First Commission, and its apparently complete organization makes it look like Portland will soon be a mighty safe place to move around in. Man named Coffin is the chairman—no, he's a live one.

* * *

Some day we are going to cast a form for use in newspaper offices when reporting a boiler explosion. Here are some expressions that the censor will delete: "Escaped in a miraculous manner"; "hurled this mass of metal"; "it went up in the air straight as an arrow, carrying the steel roof with it"; "it blew out with terrific force"; "windows were shattered"; "concussion from the explosion";; "cause was low water"—and somewhere in the form will be this line: "If you can't find out the reason, don't fake one."

* * *

Pretty clever wording that, "Electricity the heart beat of modern warfare." But, "Peace hath her victories no less renowned than war." So let us hope that the plowshare of peace will soon drive a deep furrow through these now bloody fields of Europe and that the sun will shine down once more upon those desolated homes and bring up a harvest of happiness and prosperity. Speed the day!

* * *

To increase the use of its current, a Kansas City lighting company had demonstration days, one for washing, one for ironing, and one "when the more delicate dishes were given prominence." What's indelicate about washing and ironing? Oh, Mama, may I go out to swim?

* * *

Elevators were known as far back as 300 B. C., we were told by a wise geek at New York's electrical show. Yes, but that city is rapidly replacing them. By 2001 this type of lift will be only a memory.

* * *

Uncle Sam's navy has keen competition in its midst in the individual coaling of its ships. The dreadnaught "Arkansas" has made a record of stowing 560 tons in its bunkers in 60 minutes.

* * *

But the "Kronprinzessin Cecilie" had one true heart aboard, writes a visitor who saw her shortly after her capture, and here comes a fine touch of humanity. After making the round of the ship, our chief engineer found in the cabin assigned him a blotting-pad with a farewell message. There were none of the German jeers you might expect, but penciled appeals in broken English to clean the engines "twice weekly," to feed the "pidgons" on the "uper deck," and to "oel" the piston-rods regularly for the very good reason that "paking is cast-iren and will be rosting." It seems that the Ober-Ingenieur who wrote this note had superintended the building of the ship in the Stettin yards, and when he took leave of her at Falmouth, they say he sobbed like a woman bereft of a child Doubtless in the Babylonian captivity of Bodmin he wonders how the engines that he loved are faring, and it should comfort him to know that they are in good hands. Moreover, his blotting-pad message now adorns a British officer's album as so much proof that a true McAndrews may bear a German name.

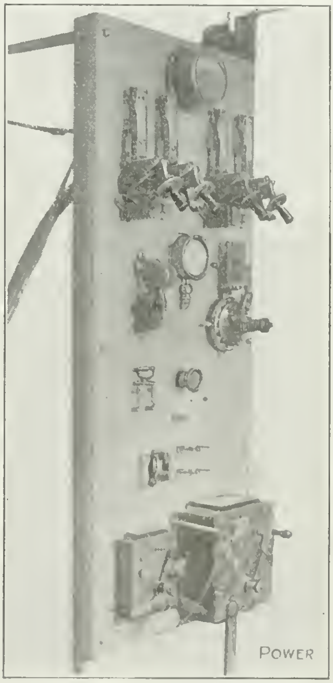
Brother Harris, Lachine, Que., sent us this corking good heart-throb from the "Montreal Star."

Electrical Control of Isolated Vacuum Heating Apparatus

By H. G. Gibson

The power plant with which the writer is connected takes care of several buildings. One of them, recently constructed, is some distance from the power house. The heating and ventilating plant in this building consists of a double-duct forced-air system, the air being heated by exhaust steam, aided by live steam in very cold weather. The steam coils are operated on the vacuum system, the condensation being removed by means of a motor-driven centrifugal pump. The air-circulating fan is also motor-driven.

Because of the isolated position of the building with relation to the main engine room, it is not possible for the engineer to remain continually with the heating apparatus. It is obvious that should the vacuum pump stop for any reason, the coils would soon fill with water. If the outside temperature were below freezing and the air-circulating fan continued to run after the vacuum pump stopped, probably some frozen and burst coils would be the result.



Switchboard with Pump, Fan and Vacuum Control

To lessen the chance of such an occurrence the following arrangements were made: On the switchboard, with the rest of the pump and fan-controlling apparatus, was mounted a diaphragm circuit-breaker, shown at the center in the illustration. This and the vacuum gage, in the center of the board, are piped in parallel to the suction side of the vacuum pump. When the pump maintains a vacuum on the coils, it also acts on the diaphragm switch (just above the spring), closing it. The closure completes a circuit through the coil of a solenoid-controlled, quick-acting circuit-breaker, shown to the left of the vacuum gage, this breaker being in the air-circulating fan-motor circuit.

Thus it will be seen that if for any reason the vacuum pump stops, or for any other reason a vacuum is not maintained, the diaphragm spring will open the switch to which it is connected. This breaks the circuit in the solenoid, allowing its contacts to open, thus breaking the circulating fan-motor circuit and stopping the fan.

Part of a signal apparatus for notifying the engineer when the fan has stopped is shown at the left of the air-fan starting box near the foot of the switchboard. It consists of a piece of fiber, to which two brass flexible contact strips are attached. This is so fastened to the switchboard that when the fan stops and the starting-box arm falls back, it will cause the two contacts to touch and complete a battery bell circuit to ring a bell in the engine room.

⁂

Small Hydro-Electric Plant Damaged by Flood

By C. V. Hull

The floods of the Cedar, Little Cedar and Shellrock rivers of central Iowa were unusually destructive this year, causing considerable property damage, and the dam at Marble Rock, on the Shellrock River, was seriously damaged.

The dam, and the small but uptodate power house, were completed in the fall of 1913; the only unsatisfactory part of the installation was the foundation for the dam. A view of the generating apparatus is shown in Fig. 1.

When plans were made for the plant, explorations of the river bottom showed that it was some 40 ft. to bedrock. It seemed inadvisable to build the dam on rock and consequently the power house and the dam were built on a foundation of piles with a cement cap.

When the high water came, the unusual pressure and current caused erosion and movement of the river bed, so that water passed under the dam. When this was noted, the flood gates were immediately opened wide, but despite this relief the water continued to carry away the dirt and piles until the volume of water passing under the dam was greatly increased. Probably 15 or 20 ft. of the foundation was washed out, but the dam was so well reinforced that it stayed in position with part of the foundation gone. Fig. 2 shows the water at its highest stage.

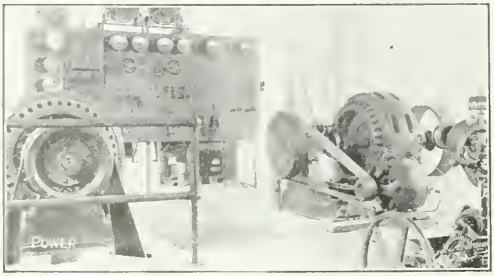


Fig. 1. View of the Station Apparatus

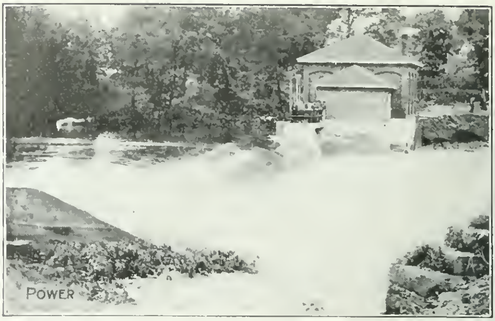


Fig. 2. Exterior of the Power Plant: Water at Highest Stage

The damage done to the plant will make it necessary to put about $15,000 into the repair work, and a new bridge will cost about $20,000 to replace the one carried away.

While the water power was out of service, a kerosene tractor outfit furnished power to run one of the alternators, which was turned at right angles to its former position, the belt being run through the door of the building, Fig. 3. This makeshift gives service from 14 to 16 hours per day.

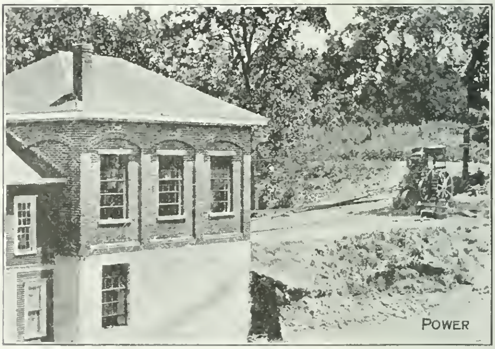


Fig. 3. Tractor Engine Belted to Generating Unit through Door

As soon as the dam can be repaired, the original equipment will again be put in service. In it are two water, vertical-shaft turbines, belt-connected to three-phase, 60-cycle, 2400-volt alternators, running at 400 r.p.m. The generators and turbines are arranged for parallel operation. The switchboard is neatly arranged, with all the necessary switches and instruments. Current is furnished to the consumer at 104 volts. The exciters run at 1550 r.p.m. and generate 28 amperes at 125 volts.

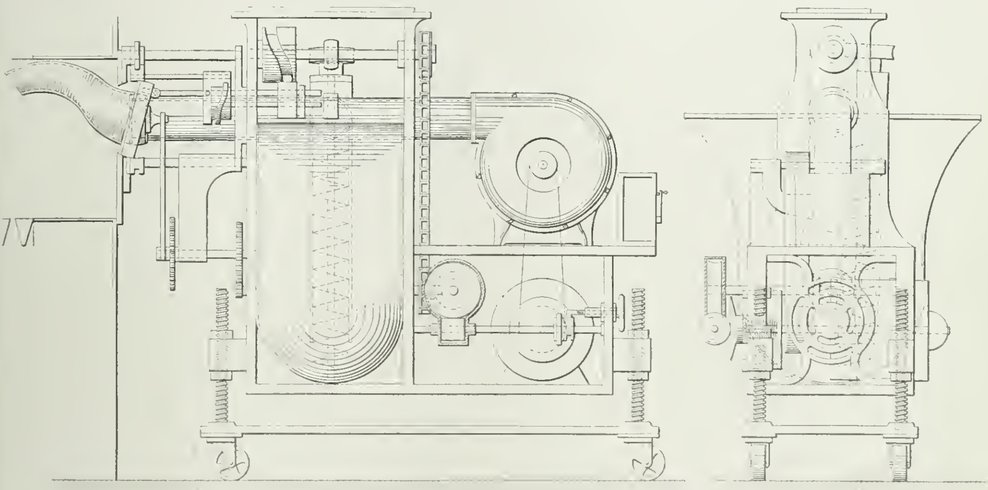
Since the turbines have vertical shafts, quarter-turn idlers are necessary to make the belt turn to the generators. They are secured to heavy frames, molded into the heavy cement walls of the buildings; this insures a substantial and accurate lineup.

The plant was put in for the benefit of residents of the town, who wanted day-and-night service.

Cooke Mechanical Stoker

A mechanical stoker embodying new features is illustrated herewith. It is attached to the boiler front by simply opening the door and running the discharge nozzle into the opening. The stoker is run by a ¼- to 1-horsepower motor, according to the size of the boiler. The motor is placed underneath the blower, the latter being driven by a belt from the former; the pipe which conveys the coal to the oscillating nozzle is attached to the blower.

The hopper is in the middle of the machine, the top of which stands about 40 in. above the floor. Coal is lifted out of the hopper by a screw conveyor into the side of the pipe and is then carried by the force of the air from the blower onto the fire. The coal and air in passing through the nozzle, absorb heat and the fuel is deposited on the fire hot; at the same time the nozzle itself is prevented from becoming overheated by the passing of this coal and air through it.



Details of the Cooke Mechanical Stoker

The coal is bituminous slack, and the stoker will operate on any coal that will pass through a ¾-in. mesh screen. By the mixture of oxygen with the coal, the finest of the coal or the dust is aflame immediately upon leaving the nozzle, and the larger particles are burst open by the heat, liberating the gases, which are immediately consumed, with the result that there is an incandescent fire in the furnace. The feed of fuel and the air supply are under perfect control, and the faster the feed, the hotter the fire.

Being adaptable to all sizes of boilers and mounted on wheels, the stoker is easily moved up to or away from the boiler. The hopper will hold about 350 lb. of coal.

The stoker is manufactured by W. H. Cooke, 325 Granite Bldg., Rochester, N. Y.

* * *

Wastes Around Power Plants—Wastes around the power plant may be reduced somewhat by the covering of all hot surfaces, such as small air-separating and other tanks which receive the condensation from vacuum-return systems, or from drips, etc. All drips should be covered when the condensation from the drips is not wasted to the sewer

Annual Meeting of the A. S. M. E.

The annual meeting of the American Society of Mechanical Engineers will be held at the home of the society, the Engineering Societies Building, 29 West Thirty-ninth St., New York City, Dec. 1 to 4.

It is expected that two features of the annual meeting alone will make it distinctive and of widespread interest. The first of these is the important all-day session on Thursday, Dec. 3, on the Engineer in Public Service, when papers upon municipal engineering and related topics will be presented. Contributions have been arranged for upon a wide variety of subjects as is indicated in the following tentative list:

The collection and disposal of refuse from an engineering standpoint and the utilization of municipal wastes; the handling of sewage sludge; the training of municipal employees; the cleaning of public buildings; the future of the police arm presented from the engineering side; the problem of organization as related to the highway department; controlling factors in municipal engineering; cleaning filter sands; the design and operation of a municipal electric-light plant; and municipal colleges in Germany. The session will be opened by John Purroy Mitchel, mayor of the City of New York. Arrangements for the session are being completed by the committee on public relations, and it promises to be one of the most attractive and largely attended meetings which the society has held.

The other feature is that of the reports which are expected for the Wednesday morning session. As is known to the membership, two of the most important reports ever undertaken by the society are nearing completion, and it is hoped that both can be presented at the coming annual meeting.

One report is that of the power test committee, which was published in preliminary form in the society's "Journal" nearly two years ago. Since then the report has been thoroughly revised and is now being put into its final form. It attempts to standardize the methods of testing the various types of prime movers and auxiliary apparatus, and is so broad in its scope that it will interest a large number of members. It is expected will constitute one of the most comprehensive publications that the society has ever issued.

The report of the committee on standardization of steam boilers is equally voluminous, and is also approaching its completed state. Its value both to engineers and the public at large is so great that it can scarcely be estimated, involving as it does every item of consequence in relation to the safety of steam boilers, from the specifications of steel to the qualifications of the men in the boiler room.

An interesting session, in charge of the subcommittee on iron and steel, will be devoted to subjects relating to cast iron and steel from the standpoint of the mechanical engineer. New developments in the field of engineering metals will be dealt with in a way to bring out and make these recent advances a matter of common knowledge. Other sessions in charge of subcommittees will be those on machine-shop practice and on railroads. At the latter there will be a report by the subcommittee on railroads, on the steam locomotive of today. Copies of individual papers have been received from other subcommittees, and one session will be devoted to a number of miscellaneous papers of exceptional merit. The subjects will be announced later, when the complete program for the meeting will be published.

The president's reception will be given on Tuesday evening during the convention, and on Wednesday evening there will be a lecture upon a subject to be announced. The reunion this year is expected to take the form of a dinner dance at the Hotel Astor, and this will constitute the chief social event of the meeting. Covers will be laid for at least 350, and there will be dancing between courses. The grand ball room at the Astor has been engaged for this occasion.

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Power on the Pacific Coast

In an address before the recent convention of the northwest Electric Light & Power Association at Spokane, Wash., W. E. Herring of the Puget Sound Traction Light & Power Co. showed that the Pacific Coast during the past few years has come forward with a greater increase in water power development than any other section of the United States.

The electrical energy as a whole is increasing at a tremendous rate. At the end of 1912 the total kilowatt rating of generators in the United States was in excess of 5,000,000, an increase of 323 per cent. in ten years. In no other industry has there been such an increase in capital, it now exceeding $7,000,000,000 and for the five-year period up to 1912 there was required an average of $180,000,000 a year for central station work alone.

Bringing the argument home to the Pacific Coast, Mr. Herring showed that the new capital needed on this slope in the next ten years would be from $150,000,000 to $250,000,000, depending to a great extent upon the number of new industries that can be brought to this section and upon the amount of electrification done by steam roads.

The minimum potential water power in the country shows a total of 26,736,000 hp., of which 4,932,000 is available in Washington, 3,148,000 in Oregon and 3,424,000 in California. The total for the three states is 11,504,000 hp, or nearly 43 per cent. of the total potential water power of the United States. Washington has developed 306,000 hp. or 6 per cent. of the possible power; Oregon 105,000 hp. or 3 per cent.; California, 430,000 or about 8 per cent.

With this wealth of power it is shown that in practically all of the Coast cities the value of the manufacturers' products is less than in a majority of Eastern cities of similar size; but it is believed that with a rapidly increasing population, the Panama Canal, and the opening of Alaska this condition will change.

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Power Development in British Columbia

The Canadian Western Power Co. is making important improvements and increasing the capacity of its plant at Stave Falls, British Columbia. A 13,000-hp. turbine, a 900-hp. generator, a 3000 kw. transformer and a large outfit of switchboards will soon be installed for use in connection with the third unit of the plant, the buildings for which are nearing completion. The company has a capacity of 25,000 hp. Later, with the installation of the third unit, the plant will have 37,000 hp., and by next year will be generating over 50,000 hp. with four units in operation.

The new hydroelectric plant for Kamloops will get its power from the Barriere River. The power house building has been completed, the machinery is being erected and the city of Kamloops will be utilizing the current carried over the new line within a few weeks. The first unit will produce 2600 hp. and later the capacity of the plant will be increased to 8000 hp.

The city council of Revelstoke has awarded contracts for the improvement of the civic water power plant to Escher, Wyss & Co., Zurich, Switzerland, for a water turbine with a 44-in. valve, and to the Westinghouse Co. for a generator, exciter and switchboard. The total cost of the improvements will be about $20,000.

The Canadian Northern Ry. is developing a 50,000-hp. plant from the Sumallo and Nicaloon Rivers, which will be employed in operating the Canadian Northern trains from Port Mann to the False Creek terminals at Vancouver, B. C.

Announcement has just been made of the proposed construction of a large hydroelectric plant, to represent at its completion an expenditure of several millions, and to be on the Speel River, 35 miles south of Juneau, Alaska. The government has issued a grant for the projected undertakings and actual construction work is expected to start in a few months. The plant will have a capacity of 100,000 hp.

*

Salt Lake City to Investigate Smoke Nuisance

If Salt Lake City, Utah, will make the necessary appropriation, the metallurgical bureau of the Univeraity of Utah will undertake a systematic study of the smoke problem in Salt Lake.

A resolution recently adopted by the board of governors of the Commercial club was forwarded to the city commission asking that an appropriation to cover the cost of the investigation be made. The resolution was accompanied by a plan for a systematic investigation, evolved by Prof. D. A. Lyon, government expert in charge of the university bureau. In a letter to the city commission George W. Snow recommends that the officer of the United States Bureau of Mines at the University of Utah be allowed to conduct an investigation as to the smoke nuisance in Salt Lake, and that the city make an appropriation to cover the cost of the investigation.

*

Drought Shuts Down Plants

A large number of industrial plants in Pennsylvania, especially in the western section, have been compelled to shut down temporarily for lack of water. The long drought has dried up rivers and smaller streams upon which many companies depended for their water supplies. Some of the big coal companies are compelled to haul water long distances in order to keep their power plants in operation. West Virginia and Ohio report similar conditions. The drought is the worst that has visited the section in many years.

*

Conference of Mayors at Philadelphia

When it is remembered that over eight billion dollars are invested in electric light and street-railway companies alone in this country, five and one-half billions being controlled by holding companies, it will be realized what a stupendous task a single city has when, unaided, it asks for adequate rates and proper service from the public utilities.

This condition is largely responsible for the formation of the Utilities Bureau under the sponsorship of Mayors Blankenburg of Philadelphia, Mitchel of New York, Harrison of Chicago, Baker of Cleveland and Shroyer of Dayton. Its object is to secure fairer rates and better service standards from municipal utilities through the coöperation of public officials and interested citizens. The bureau is nonpartisan and at the service of those citizens and officials who need advice and seek data concerning other utilities than their own.

A conference of mayors will be held in Philadelphia on Nov. 12, 13 and 14. The program is as follows:

Reception Bellevue-Stratford Hotel, Thursday evening, Nov. 12. Address of welcome, Hon. John K. Tener, governor of Pennsylvania.

First Session—Bellevue-Stratford Hotel, Broad and Walnut Sts., ball room.

Friday Morning, 10:30 o'clock—"Practical Utility Problems." Presiding officer, Hon. Rudolph Blankenburg, mayor of Philadelphia. Addresses: "Fundamental Planks in a Public Utility Program," Delos F. Wilcox, franchise expert, New York; "The Regulation of Municipal Utilities," Nathaniel T. Guernsey, general counsel, American Telegraph & Telephone Co., New York; "Philadelphia's Transit Problem," A. Merritt Taylor, director of city transit, Philadelphia; "Municipal Lighting Rates," Ray Palmer, commissioner of gas and electricity, Chicago, Ill.; "Labor's Interests in Public Utilities."

Second Session—Bellevue-Stratford Hotel, Friday afternoon, Nov. 13, 2:15. "The Regulation of Utilities." Addresses: "Some Present Day Issues in Regulation," Edward W. Bemis, Chicago, Ill., member of board of supervising engineers, Chicago, valuation bureau of public utilities commission of the District of Columbia: "What Certain Cities Have Accomplished Without State Regulation," Stiles P. Jones, secretary, Voters League, Minneapolis, Minn.; "A Constructive Policy for Public Service Corporations," Charles Day, of Day & Zimmerman, Philadelphia; "What Regulation Must Accomplish If It Is To Be Permanent," Hon. John M. Eshelman, president, railroad commission of California.

Third Session—Central High School Assembly Room. Under the auspices of the American Academy of Political and Social Science, Friday evening, Nov. 13, 8:15. "Local and State Regulation of Municipal Utilities." Presiding officer, Hon. John Purroy Mitchel, mayor of New York. Addresses and Discussion: Hon. Halford Erickson, member of railroad commission of Wisconsin; Hon. Milo R. Maltbie, member of public service commission for the first district of New York; Prof. Charles E. Merriam, professor of political science, University of Chicago; Hon. Ira W. Stratton, mayor of Reading, Penn.

Fourth Session—Bellevue-Stratford Hotel Ball Room, Saturday morning, Nov. 14, 10:30. "Municipal Ownership and Operation." Presiding officer, Hon. Newton D. Baker, mayor of Cleveland, Ohio. Address—"Municipal Ownership—The Testimony of Foreign Experience," Frederick C. Howe, commissioner of immigration, New York. Fifteen-minute reports from the managers of typical municipal plants. Open discussion led by Clarke M. Rosecrantz, of general counsel, Milwaukee Electric Ry. & Light Co., Hon. Robert Crosser, United States congressman from Ohio, member of committee on the District of Columbia.

Fifth Session—Saturday afternoon, Nov. 14, 2:15. Executive session, open only to mayors and delegates. Round table discussion: "Elements in a Constructive Utility Program."

Sixth Session—Witherspoon Hall. Under the auspices of the American Academy of Political and Social Science, Saturday evening, Nov. 14, 8:15. "Holding Companies and the Public Welfare." Presiding officer, Hon. Franklin K. Lane, secretary of the interior, Washington, D. C. Addresses and discussion: Francis T. Homer, Bertron, Griscom & Co., New York; Charles F. Mathewson, of counsel, Consolidated Gas Co., New York; James P. Goodrich, director, National City Bank, Indianapolis, Ind.; Louis D. Brandeis, lawyer, Boston, Mass. The attendance of 106 mayors or their delegates has been promised for the conference.

TRADE CATALOGS

American District Steam Co., North Tonawanda, N. Y. Catalog No. 9. Steam heating specialties. Illustrated, 234 pp., 6x9 in.

Sprague Electric Works, 527-31 W. 34th St., New York. Bulletin No. 48,701. Electric Dynamometers. Illustrated, 24 pp., 8x10½ in.

The Ohio Blower Co., 5130 Perkins Ave., Cleveland, Ohio, The HANDiLINE HANDiBOOK. Sheet metal and angle iron specialties including refuse boxes, cans, racks, battery cases, etc. Illustrated, 3½x6 in.

Ingersoll-Rand Co., 11 Broadway, New York. Form No. 4033. "Little Tugger" air hoist for power plants, etc. Illustrated, 8 pp., 6x9 in. Form No. 8013. "Little David" pneumatic chipping, calking and scaling hammers. Illustrated, 12 pp., 6x9 in. Form No. 8207. "Little David" pneumatic drills. Illustrated, 36 pp., 6x9 in.

NEW PUBLICATIONS

MINERS' CIRCULAR 16. Hints on coal-mine ventilation, by J. J. Rutledge. 1914. 22 pp.

TECHNICAL PAPER 65. A study of the oxidation of coal, by H. C. Porter and O. C. Ralston. 1914. 30 pp., 12 Figs.

NEW GOVERNMENT PUBLICATIONS—The Bureau of Mines, Department of the Interior, announces the following new publications:

TECHNICAL PAPER 93. Quarry accidents in the United States during the calendar year 1913, compiled by A. H. Fay. 1914. 66 pp.

TECHNICAL PAPER 81. Production of explosives in the United States during the calendar year 1913, by A. H. Fay. 1914. 13 pp.

BULLETIN 83. The humidity of mine air, with especial reference to coal mines in Illinois, by R. Y. Williams. 1914. 69 pp., 7 Figs.

NOTE—Only a limited supply of these publications is available for free distribution, and applicants are asked to coöperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers cannot be granted without satisfactory reason. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

SIMPLE PROBLEMS IN MARINE ENGINEERING DESIGN—By J. W. M. Sothern, Principal, Sothern Marine Engineering College, Glasgow. Third edition. James Munro & Co., Ltd., Glasgow; D. Van Nostrand Co., New York. 191 pages; 5x8-in. semi-flexible cloth. Price, $1.

This work contains data and methods of solving problems of design of boilers and engines, reduced to simple arithmetical and algebraical processes. The test questions under each head afford valuable information and practice for young engineers and candidates for licenses who may wish to refresh their knowledge of engineering calculations.

POCKETBOOK OF MARINE ENGINEERING RULES AND TABLES. By A. E. Seaton and H. M. Rounthwaite; 12th edition, with diagrams. London, Charles Griffin & Co.; New York., D. Van Nostrand Co. Flexible leather; 4x6½ in.; 713 pages. Price $3.50.

This pocketbook, which in Great Britain is known as a standard, is a compendium of rules, tables and data that should find a welcome place in the kit of every marine engineer. The rapid modifications of conditions in marine engineering of recent years, such as the adaptation of turbine and internal-combustion engines to propulsion of ships, have called for convenient form of additional data not included in earlier editions of this work. The authors have also included new Rules of the Board of Trade and the more recent modifications of Lloyds and other registry societies.

PUMPING BY COMPRESSED AIR—By Edmund M. Ivens, M. E. First edition. New York, John Wiley & Sons. 244 pages; 6x9 in.; 106 illustrations; cloth. Price, $3.

Literature on pumping by compressed air has heretofore been almost exclusively confined to air compressor catalogs, articles scattered through the proceedings of technical societies and some data to be found in works on compressed air which were either a repetition of material contained in catalogs or of a purely theoretical character.

The work will therefore be appreciated by engineers and others for its systematic and practical presentation by an author who has had the opportunity to install and test a number of air lifts operated under a wide range of conditions and is fortified by valuable data. The work places before the student a comprehensive theoretical study of the subject and at the same time imparts easily understood instruction to the operating engineer in the economic essentials of the practical installation.

In addition to the space devoted to design and operation of air lifts, the work contains good descriptions and illustrations of various commercial and return systems, and for greater completeness of the subject of compressed air pumping, the later chapters are devoted to pertinent principles of hydraulics and thermodynamics. The concluding chapters treat of air compressors, flow of compressed air in pipes and flow of water in pipes.

"VERBAL" NOTES AND SKETCHES, FOR MARINE ENGINEERS. By J. W. M. Sothern, Principal, Sothern's Marine Engineering College. Glasgow, James Munro & Co., Ltd.; New York, D. Van Nostrand Co. 676 pages. 6x9 in.; illustrated; cloth. Price, $5.

The former editions of this work are well known to the engineering profession, especially to those specializing in marine-engineering construction and operation The work is systematically divided into ten sections and an appendix treating of workshop practice, in which are described such subjects as types of engines, design and construction of parts, auxiliary machinery, trial trips, etc.; marine-boiler construction and management; notes and sketches of various details; valves and valve data; general notes on designing and repairing of parts and marine-engineering operation. marine-engineering chemistry notes embracing practical chemistry of combustion, feed water and boiler and condenser corrosion; marine electric lighting; propellers; refrigeration, and internal-combustion engines; together with an appendix on marine steam turbines, air pumps and various details.

The work is to be especially commended for the thoroughness and completeness of treatment, good presentation and excellent illustrations, most of which are drawn to scale with the parts especially referred to emphasized with appropriate shading. The work is an excellent textbook for students and apprentice engineers and a valuable reference handbook on British marine engineering.

ENGINEERING AFFAIRS

Annual Meeting of Massachusetts Chapter, A. S. H. & V. E.

The annual meeting of the Massachusetts Chapter of the American Society of Heating and Ventilating Engineers was held Oct. 13, at the Revere House, Boston, Mass., with a large attendance. The principal business was the election of officers which resulted in the following: Andrew G. Paul, president, Eugene R. Stone, vice-president; Charles Morrison, secretary; William T. Smallman, treasurer. Board of Governors: William G. Snow, Frank Irving Cooper, James W. H. Myrick. There is a good balance in the treasury. Several new members were admitted and a general feeling of enthusiasm and coöperation prevailed which bids fair to continue throughout the year. Resolutions were engrossed on the recent death of Albert Barnes Franklin, who was active in the society, having been second vice-president.

Pennsylvania Department of Labor and Industry—In accord with the unanimous vote of the first Pennsylvania Industrial Welfare and Efficiency Conference held in Harrisburg, Penn., last year, Commissioner Jackson has issued a call for a second conference to be held in the State Capitol at Harrisburg on Nov. 17, 18 and 19. This conference is held under the auspices of the Pennsylvania department of labor and industry and the Engineers Society of Pennsylvania. The purpose is to enable the employers and employees to work out together the great problems before them with reference to increasing the welfare of the employees and the prosperity of the industries. The conference last year was attended by some 2000 persons, many of whom were leaders in the labor and industrial world. The gathering this year bids fair to have an even larger attendance and to create even more interest than that of last year.

In connection with the conference proper, will be held an unusually effective safety, welfare and efficiency exhibition which will open on Nov. 16 and close on Nov. 20.

The commissioner believes, both from the unusual value of the conference last year and the even more positive purposes of the present conference, that a great amount of work can be accomplished this year. He therefore earnestly calls upon every broad-minded citizen who is interested in industrial affairs to come to Harrisburg at the time of the conference and take an active part in the proceedings.

PERSONALS

Paul Bigelow, Eastern manager of the Buckeye Engine Co., addressed the Brooklyn Engineers' Club, 117 Remsen street, Brooklyn, N. Y., on the evening of Oct. 29 on the Buckeye-mobile.

George H. Chandler, a stationary engineer for more than 50 years, and for the past 17 years the chief engineer of the Bryant Paper Co., Kalamazoo, Mich., has retired from that position at the age of 74 years. Mr. Chandler will act as storekeeper for the company, and in recognition of his long and faithful service will draw the same salary he had while chief engineer.

Dr. John A. Brashear, Pittsburgh, Penn., has been nominated for the presidency of the American Society of Mechanical Engineers. Other nominations are as follows: For vice-presidents: Henry Hess, Hess Steel Castings Co., Bridgeton, N. J.; G. W. Dickie, San Francisco, and James E. Sague, Public Service Commission of the Second District, New York. For managers: Charles T. Main, Dean & Main, Boston; Spencer Miller, Lidgerwood Manufacturing Co., New York; Max Toltz, St. Paul, and Morris L. Cooke, director of public works, Philadelphia. William H. Wiley, John Wiley & Sons, New York, has been renominated as treasurer.

George M. Brill has been appointed director of the general reception committee for the International Engineering Congress to be held in connection with the Panama-Pacific Exposition in San Francisco next year. With headquarters in the Engineering Societies Building in New York City he is to organize reception committees in the large cities of the country. Among the members of the general reception committee are Walter M. McFarland, Babcock & Wilcox Co.; William L. Saunders, Ingersoll-Rand Co., New York; E. D. Meier, Heine Steam Boiler Co.; Ambrose Swasey, Warner & Swasey Co., Cleveland; Howel H. Barnes, Jr., General Electric Co.; Stevenson Taylor, Quintard Iron Works, and Dr. A. C. Humphreys, Stevens Institute of Technology.

OBITUARY

CURTIS E. WHITTLESEY

Curtis E. Whittlesey, for many years treasurer and secretary of the McGraw Publishing Co., died at his home in Madison, N. J., on Oct. 9, in his 72d year.

During the 24 years Mr. Whittlesey spent in the publishing business he gained for himself a host of friends who honored and loved him for his gentleness and his unostentatious deeds of real benevolence. His knowledge of finance made him frequently sought after by business men who valued his discernment and business acumen very highly.

JOSHUA H. MILLETT

Joshua Howard Millett, president of the Crosby Steam Gage & Valve Co., died at his home, Malden, Mass., on Oct. 15, of hardening of the arteries, aged 72 years, 6 months, 28 days. He had been ill but a few days and was at his office in Boston within three weeks.

Mr. Millett was born in Cherryfield, Me., and was graduated from Colby University and was later admitted to the bar. For many years he practiced successfully in Boston, but retired from active practice in 1895 to devote his time to the concern of which he was the head. When admitted to the bar he became a member of the firm of Redfield, Herrick & Millett, of which Judge Isaac Redfield was the head.

He came to Malden in 1869 and was soon identified with the welfare of the town. He was elected to the House in 1884 and 1885 and served on the committee on judiciary and the special committee on establishing the metropolitan police. He was a member of the special commission to revise the city charter and served on the park commission and school committee and was for a time a trustee of the public library. He also served on the committee to erect the soldiers monument. He was urged several times to take the mayoralty and to stand for the senate and for congress but in later years refused all political honors.

He was a member of Converse lodge of Masons, Tabernacle chapter, Melrose council and Beauseant Commandery, the Historical society, the Sons of the American Revolution and the college Greek letter fraternity of D. K. E. For many years Mr. Millett was Malden's leading Unitarian layman and was much interested in the Home for Aged Persons and was president of the corporation from its incipiency until his death. Mr. Millett was a patron of art to a considerable extent and many fine paintings hung in his beautiful home.

An officer of the Crosby company who was closely associated with Mr. Millett has this to say of him: "In my own varied business experience, I have come into close contact with a great many men, of many types; but I have never known another of his like, and his many personal and business acquaintances have used these same words in regard to him during all the past 10 years that I have known him intimately. This is merely to give an idea of how he was regarded by those who could best estimate him, and possibly to throw a side light upon the controlling policy which has established the Crosby company upon a high plane of reputation and accomplishment."

Besides his widow he leaves a son, Charles H. Millett, associated with him in business and a daughter, Mrs. Alfred B. Carhart of Winchester.

Massachusetts Board of Boiler Rules Hearing

On Thursday, Oct. 15, the Massachusetts Board of Boiler Rules held the hearing prescribed by the statute under which it is appointed, and discussed the proposed changes which were published on page 395 of our issue of Sept. 15. The hearing was attended by about one hundred engineers, and the remonstrance against making any change in the rules in advance of the publication of the report of the committee on uniform boiler specifications of the American Society of Mechanical Engineers, was practically unanimous, the only interests appearing to favor the holding aloof by Massachusetts from the nation-wide effort to obtain uniform laws appearing to be the boiler manufacturing interests of that state.

The proposed change which occasioned the most discussion was that reducing water-tube boilers with cast headers to 15 lb. pressure, which would put millions of dollars worth of water-tube boilers already installed out of service. It was shown that owing to improved methods of manufacture, the cast header is being gradually abandoned, and that the history of its use does not show it to be so serious a menace as to warrant such drastic legislation.

There are at least three, and perhaps four, courses open to the board; one to reject the proposed changes in toto; the other to adopt them in toto; the third to revise them in accordance with the light evolved by the hearing, and holding a new hearing after the advertisement required by law; or perhaps to adopt such of the changes as commend themselves to the board after the discussion. If any attention is to be paid to the sentiments expressed at the hearing, nothing will be done until the final report of the American Society of Mechanical Engineers' committee is submitted to the December meeting of that society.

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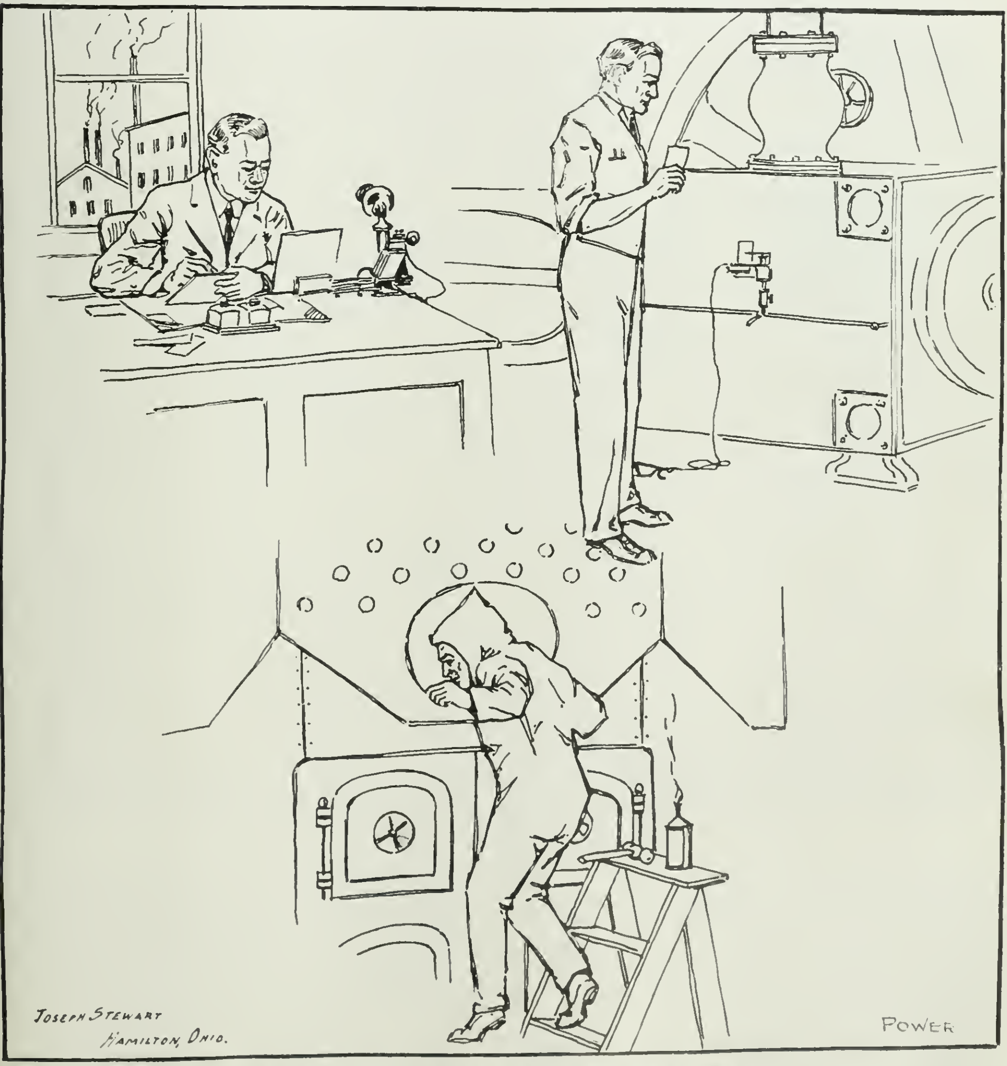

A REAL CHIEF ENGINEER

La Salle Plant Saves $45,000 Annually

By Thomas Wilson

SYNOPSIS—By intelligent supervision, the stopping of steam leaks to the atmosphere, and remodeling the boiler furnaces so that evaporation was increased 60 per cent., this enormous saving over the previous cost of operation was effected.

In 1909 the power plant in the La Salle Hotel, Chicago, was put into commission. It was equipped with good machinery and was well laid out, but unfortunately it was not operated efficiently—in fact, the operating costs were so high that at one time central-station current was seriously considered. A new engineer, W. W. Bird, came to the rescue, and as he was backed by a progressive manager, Ernest J. Stevens, who came on about the same time and incidentally has increased the business of the hotel 30 per cent., an enormous saving was made in the operating expenses.

For the year 1913, the total power-plant costs were $43,000 less than in 1910 or in 1911, and in the present year further reductions averaging between $200 and $300 per month are being made. If the results obtained in the next few months are as good, the total annual saving over the previous cost of operation will exceed $45,000 per year. This is an enormous figure, large enough to operate a power plant in any ordinary building.

In a hotel, however, there are many and varied services. The elevator load is heavy and so is the lighting; enormous quantities of hot water and steam are required, the heating and ventilation demands are usually excessive and refrigeration is needed for the kitchen, for cooling some of the larger rooms and for making ice. Then there are compressed air uses and vacuum cleaning machines, and plumbers are a necessity on the operating force. Besides, there are other services calling for men and machines, so that it will not be surprising to learn that the operating cost under the original management mounted as high as $138,000 per year. At present it is below $95,000 and for the services rendered is not excessive.

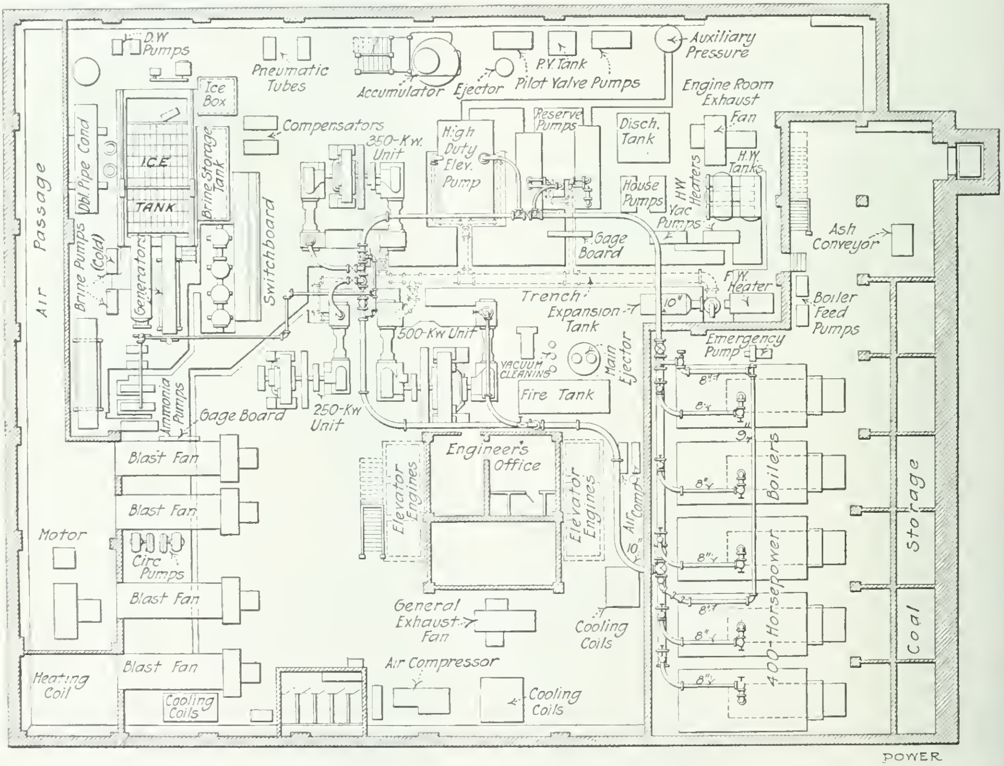

Fig. 1. Plan View, Showing General Layout of La Salle Hotel Plant

Power-Plant Equipment

It will be interesting to learn how this great saving was made, but first it will be well to know the equipment of a plant which consumes on the average 100,000 lb. of coal and 450,000 gal. of water per day of 24 hr.

The hotel is 22 stories high, measures in plan 162.5x178 ft. and contains 1172 rooms. The plant occupies the subbasement; its general layout is shown in Fig. 1. There are five 400-hp. combination fire and water-tube boilers, which are served by chain-grate stokers, and originally there was a large ash-storage capacity at the end of the grates. At this point a special dump box was provided.

In generating capacity there is a total of 1100 kw., made up by three directly connected units. The largest has a capacity of 500 kw. and the prime mover is a cross-compound engine with cylinders measuring 20 and 32x36 in. Another 17 and 28x30-in. cross-compound engine drives a 350-kw. generator, and the third is a 250-kw. unit with a simple 19x30-in. engine. Direct current is generated and distributed at 110-220 volts on the three-wire plan. The normal load averages close to 400 kw., while the connected load is about 900 kw.

Heating in the smaller rooms is effected by direct radiation, while in all the large rooms, dining rooms, banquet halls, etc., the heating is indirect. An extensive system of ventilation replaces the air of the entire building every six minutes. In the summer, cool air is supplied to the public rooms and banquet halls by a 100-ton absorption refrigerating system. A similar outfit rated at 50 tons makes on an average for the year 10 tons of ice per day, and cools the drinking water and 53 refrigerators. These systems use exhaust steam from the auxiliaries at a pressure of ½ lb. to 15 lb. above the atmosphere.

There are six hydraulic passenger elevators and three for freight, the pumping equipment consisting of a three-cylinder compound Corliss, high-duty, 13, 16 and 16x4¼x 13-in. pumping engine, one high-duty, 18½, 22 and 22x 5¾x24-in. pump, and a simple 12x18x4⅜-in. pump. Then there are the boiler-feed, vacuum, brine and house pumps, heaters and other auxiliary equipment described more in detail in the May 17, 1910, issue of Power.

How Saving Was Made

When the new engineer took charge, there were 22 steam traps in the building. Upon investigation, it was found that all of them leaked. A large quantity of live steam was constantly escaping to the exhaust and most of it eventually to atmosphere. These traps were replaced by eight of greater capacity and of a type which by their movement gave evidence of satisfactory operating conditions. An important leak was stopped and the engineer gave his attention to the operating schedule of the main units.

Fig. 2 shows how the electrical load varied on an average day of 1910 or 1911 and how at different periods it compared with the capacity of the three generating units. Formerly it had been the custom to run unit No. 3 from 7 a.m. to 5 p.m., units Nos. 1 and 2 from 5 p.m. to 1 a.m. and No. 1 for the balance of the time. As the load curve will show, there was no occasion to run two units at any one time and a more economical schedule was possible. It did not take long to decide that it would be better to run No. 2 from 7 a.m. to 5 p.m, No. 3 for the heavy load from 5 p.m. to 1 a.m. and No. 1 for the balance of the night. This schedule has been maintained for the past two years and has resulted in a considerable saving in steam.

A revision of the various fan-motor schedules and a change from arc to tungsten lamps in the basement, resulted in a lower kilowatt output, although 820 twenty-five-watt tungsten border lamps had been added at the fourth floor, 1350 ten-watt sign lamps on a large roof sign and a number of motors in the laundry, kitchen and new machine shop increased the connected load. Besides, a general overhauling of the steam-using equipment and the change in the schedule of the main units reduced the steam consumption so that instead of an excess of exhaust steam—which had always been the case in the past, even in winter—live steam is now needed when the temperature outside falls below 20 deg. F. Weather at this temperature occurs only a small percentage of the heating season, so that during the greater part of the colder months the plant is working under ideal conditions.

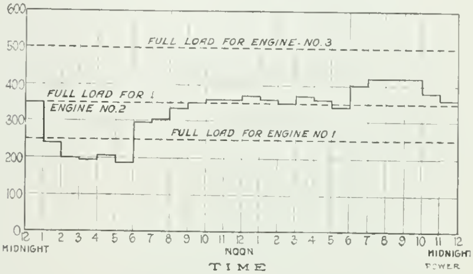

Fig. 2. Load Curve for Typical Day

The ice-making plant was also perfected and its capacity so increased that $300 worth of ice was bought in 1913, as compared to $2400 in 1911. A comparison of the tonnage is available in Table 1; in Table 2 is given the cost of purchased ice.

Greatest of all was the saving made in the coal pile by a modification in the boiler settings. Fig. 3 shows the

TABLE 1. A COMPARISON OF OUTPUT AND COAL

Months	Tons of Coal 1910	Tons of Coal 1913	Cost of Coal 1910	Cost of Coal 1913	Kw.-Hr Light and Power 1910	Kw.-Hr Light and Power 1913	Ice Made, Tons 1910	Ice Made, Tons 1913	Cost Removing Ashes 1910	Cost Removing Ashes 1913
March	2,190	1,395	$6,398.14	$3,523.93	272,830	231,100	193	262	$454.00	$141 50
April	1,888	1,206	5,996.56	3,071.62	218,160	218,460	208	259	406.00	158 50
May	1,880	1,276	6,073.68	3,222.44	244,570	222,890	234	348	352.00	157.50
June	1,770	1,161	5,728.99	2,945.42	253,010	214,490	249	368	400.00	115.57
July	1,769	1,233	5,407.01	3,115.92	218,910	211,740	248	412	408.00	136.58
August	2,068	1,250	6,205.05	3,159.09	306,970	220,485	254	419	458.00	145.13
September	2,023	1,298	6,059.35	3,198.62	307,110	219,070	246	318	481.65	164.17
October	1,780	1,365	5,338.20	3,471.41	210,130	235,000	248	297	279.05	161.70
November	1,718	1,278	5,156.40	3,229.66	279,680	228,250	213	278	202.00	118.95
December	2,032	1,315	5,913.45	3,400.38	248,570	231,590	226	268	300 00	143.60
January	2,085	1,429	5,805.00	3,611.53	320,910	243,300	226	261	379 00	159.30
February	1,623	1,338	4,706.85	3,387.58	300,000	220,070	211	232	242.00	159.30
Totals	22,826	15,577	$68,788.68	$39,337.60	3,180,850	2,696,445	2,756	3,722	$4,352.70	$1,825 10

TABLE 2. A 4-YR. SUMMARY OF OPERATING COSTS

Items	1910	1911	1912	1913
Wages	$35,885.08	$36 249.05	$35,196.58	$35,573.62
Maintenance and supplies	19,219.36	21,311 65	12,908.63	9,619.94
Coal	68,788.68	65,208.50	50,697.23	39,337.60
Ice bought	2,100.00	2,409.50	396 50	286.74
Water	11,800.00	12,844.53	11,512.50	9,908.37
Total	$137,793 12	$138,026.23	$110,711.44	$94,756.25

old arrangement. Space had been left between the end of the grate and the bridge-wall for a perforated dump box extending the full width. This box had considerable capacity and by collecting the ashes gave time for the incandescent particles carried over to give up most of their heat before being dropped into the ashpit. From this box a wedge-shaped piece projected to raise the clinker from the grate, so that it would not clog the delivery of the finer ash. The intention was good, but the result was the continual breaking of links.

As regards combustion, the air naturally took the course of least resistance, passing along under the grate to the perforated dump box at the rear or to the same spot through the plank covering the mouth of the ashpit, as indicated by the arrows. Very little of it passed through the fuel bed where it was needed, the greater quantity taking the longer but easier course through the dump box at the rear. An evaporation not exceeding 5 lb. of water per pound of coal was obtained and the average could not have been much over 4 lb. It was impossible to burn No. 5 coal, a mixture of Nos. 3 and 4 Carterville washed coal being the fuel used.

The revised furnace is shown in Fig. 4. Iron doors replace the plank flooring. Partitions in the ashpit and under the grate force the air to pass up through the fuel. The dump box was taken out and the bridge-wall carried over as shown, with a water-back to support it and at the same time better the circulation in the boiler. The result is an evaporation of 8 lb. of water per pound of coal, and the fuel burned is a mixture of Nos. 4 and 5, which can be obtained at a lower cost per ton. Now there are no leaky tubes at the back head, a common occurrence after a shutdown in the old days.

Ashes were formerly wheeled to a chute leading to the underground freight tunnel, dumped in a space provided for the purpose and then shoveled into the tunnel cars. These two handlings were reduced to one by having the ashes carted away and the cost per month to remove them was lowered from an average of $360 to $150.

Comparative Records

Table 1 compares the tonnage and cost of coal, the load, quantity of ice made and the cost of removing ashes for 1910 and 1913, the fiscal year starting in March and ending in February. Only the figures for these years are given, as the results for 1909 and 1911 are much the same. This also applies to Table 2, which is a summary of the operating costs for the four years the plant has been in operation. During 1912 the plant was being put in condition, and although a saving was made over the previous years, it is not as large as in 1913.

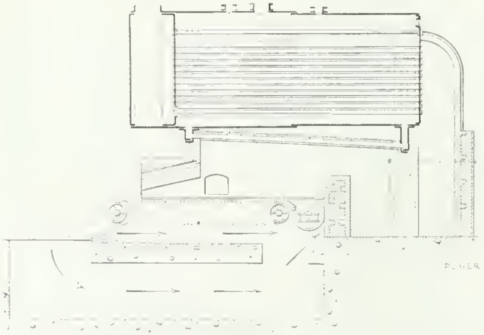

Fig. 3. Original Furnace Design

The totals in Table 1 show that the saving in coal alone was $29,451.08, due to burning less by 7219 tons and to a lower cost per ton, as by remodeling the furnace it was possible to burn a mixture of Nos. 4 and 5 instead of Nos. 3 and 4. The load is less by 481,405 kw.-hr. per year and the cost of removing ashes has been reduced $2527.60. In the ice plant the increase in output is 966 tons.

Table 2 is a summary of the operating and maintenance costs of the entire engineering force of the building from 1910 to 1913. Under the former management these costs averaged close to $138,000. In 1913 they were reduced to less than $95,000, the exact difference between 1911 and 1913 being $13,269.98. From March 1 up to the present writing there has been a further reduction of from $200 to $300 per month, so that for 1914 the saving over 1911 should exceed $15,000.

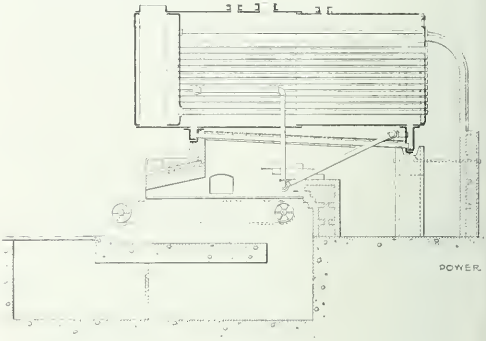

Fig. 4. The Improved Furnace

It should be borne in mind that the business of the hotel has increased 30 per cent., and ordinarily a corresponding increase would be expected in the demands on the engineering department. The showing made by Mr. Bird is then all the more creditable. It is an indication of what attention to business will accomplish in a power plant. Getting after the small leaks as well as the big ones, using rare judgment in arranging the operating schedules of the main units and auxiliaries and keeping all apparatus in first-class condition are the things that count. Add to these a good system of records showing the results obtained and an engineer who can properly interpret them, and you have in a nutshell the correct explanation of the remarkable showing made in the La Salle Hotel plant.

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Repairs to Valves—The repairs to valves in boiler plants may be facilitated by the use of one make of valves throughout the piping system. This involves the keeping in stock of but one kind of repair parts, with which the steamfitter soon becomes familiar.

⁂

Canadian City Takes Over Utilities Plant—Sault Ste. Marie, Canada, has taken over the Tagona Water & Light Co. The employees of the former water and light company will be on the city payroll under the supervision of the water and light committee.

The rates will be based on their schedule as per 100 ft. of floor space. It is the intention of the city to do away with the meter rental, which has been a source of contention in many places.

New Rotary Air Compressor

An air-cooled rotary air compressor, which at 400 r.p.m. makes 3200 compressions per minute to deliver about 75 cu.ft. of air at 100 lb. pressure, has just been placed on the market by the Wernicke-Hatcher Pump Co., Grand Rapids, Mich.

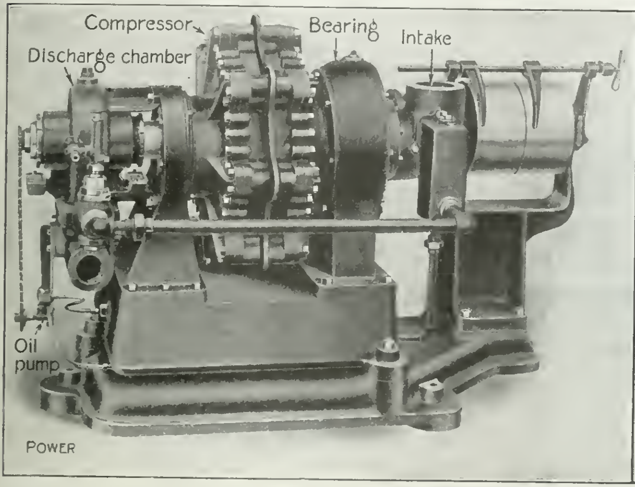


Fig. 1. Wernicke-Hatcher Single-Stage Rotary Air Compressor

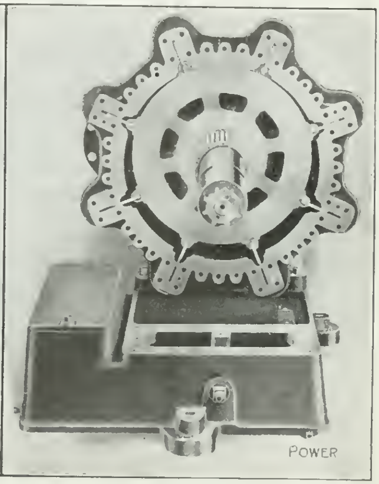


Fig. 2. Discharge End with Rear Bearing Bracket and Case Head Removed

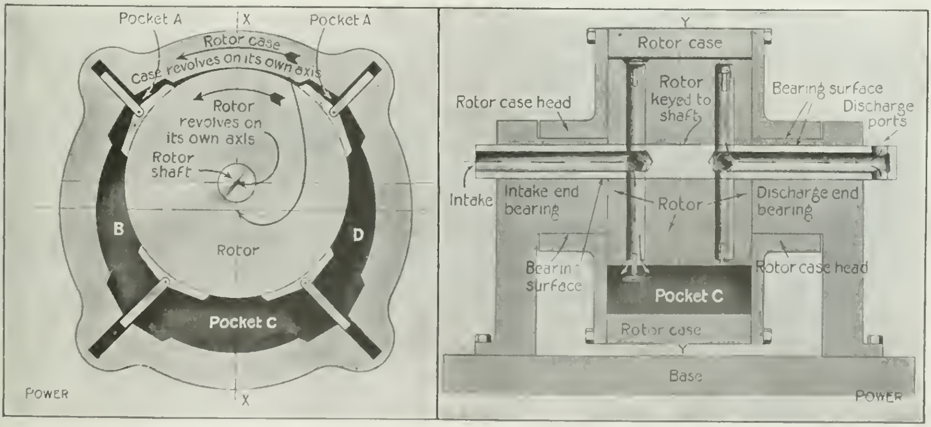


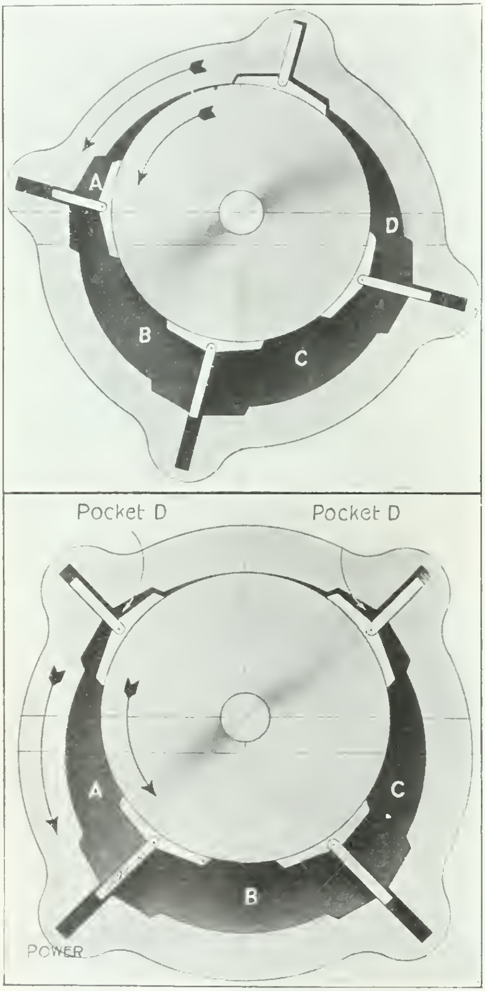
Fig. 3. End and Side Sectional Views, Showing Positions Taken by the Elements

The machine, shown in Fig. 1, weighs only 1400 lb. It is 46 in. long, 28 in. wide by 35 in. high, and is arranged for belt drive. It consists principally of two elements, a rotor and a rotor casing, both of which revolve in the same direction and at the same speed on independent axes eccentric to each other. Plates extending radially from the rotor and fitting into slots in the casing and case heads, divide the displacement of the compressor into eight independent pockets. The plates are pivoted to shoes which slide on the surface of the rotor. To allow for the eccentricity and maintain a permanent seal between pockets, the plates slide back and forth in the slots, but as the elements rotate in the same direction, the movement of the plates is relatively slow. This permits a close sealing fit on the side walls, and as the pressure in the leading pockets during compression is always greater than in the pocket behind, the plates are pressed down on the faces of the slots so that there is no leakage back to the chambers of lower pressure.

The operation may be explained by the use of Figs. 3, 4 and 5, in which for simplicity the pockets have been reduced to four. These illustrations show the successive positions taken by the compressing elements, while the compressor revolves through one-fourth of a revolution. In the Fig. 3 pocket *A* is fully contracted and has just discharged its volume of air. Pocket *B* is sucking in air, *C* is filled with air and *D* is compressing. In Fig. 4, *A* has begun to take in air, *B* is still taking it in, while

C has begun to compress and *D* has compressed still further. In Fig. 5, *A* is still drawing in air, *B* has been filled, *C* is still compressing and *D* has discharged its air. It will be apparent that as each pocket passes from the position *A* to *C*, Fig. 3, or through one-half revolution, it expands and draws in air. Through the second half of the revolution, it compresses this air and discharges it.

With eight pockets there is practically continuous compression. The periods of operation overlap so that the air is discharged uniformly at the desired pressure. This gives a steady torque on the drive shaft, and as the machine is equipped with roller bearings the friction is low. From Fig. 2 it will be evident that the clearance volume in a closed pocket is small, and another feature is the cooling surface afforded by the rotor casing. In proportion to the volume of air compressed, this surface is unusually large, and is not reduced during compression. On this account, much of the heat of compression is radiated, and on an all-day run it is reported that the temperatures will not exceed 300 deg. F. Water cooling is not necessary. The even load and easy starting permit direct connection to a high-speed electric motor with automatic starting and stopping under load if desired. This feature conserves the energy for driving, as the machine is at rest except when air is actually used.



Figs. 4 and 5. Showing Position Taken by the Compressing Elements

Each pocket is provided with an intake and a discharge valve. Both are of the ordinary poppet type, and connect through suitable passages with the intake and discharge at opposite ends of the hollow rotor shaft. The sketch in Fig. 3, indicating a longitudinal section, shows the general arrangement. The intake valves are mechanically operated by a stationary cam, the valves and lifting mechanism rotating around it. An unloader protects the machine and allows it to run idle except when air is being used.

Another feature of the compressor is the oiling system. A small pump, chain driven from the main shaft, draws oil from a large storage chamber in the base. The oil is forced up through a sight feed, then down under the base and up to the bearings. In Fig. 1 the sight feed has not been placed. A small amount of oil is also dropped into the intake to lubricate the moving parts. The overflow from the bearings returns to the tank by gravity.

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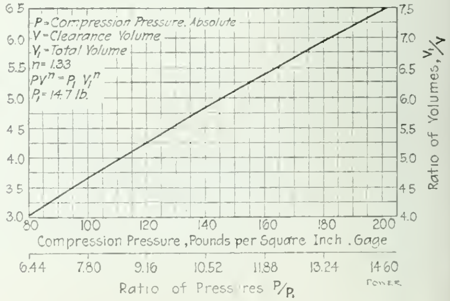
Compression Calculations for Oil Engines

By D. O. Barrett

The writer recently had occasion to make extended tests covering the determination of compression and the relation existing between the compression pressures and volumes in oil engines. The engines on which the tests were made were of the two-stroke-cycle, semi-Diesel or low-compression type, the fuel being injected directly into the cylinder by means of a pump, ignition taking place when the oil comes in contact with either a hot bulb or a plate. Since these engines have projections on the pistons, to deflect the gases, the only accurate method of determining the compression volume was by filling the clearance space with water, previously measured, and this was done in all cases. In some instances, however, a definite amount was faced off the cylinder head to decrease the compression and in these cases the volumes could easily be calculated from previous measurements; in other cases, plates were used between the cylinder head and the cylinder to increase the compression volume.



Piston Displacement vs. Compression Pressure

The effective piston displacement is represented only by that portion of the stroke to the edge of the exhaust ports, and this is one reason why two-stroke-cycle engines do not produce a greater percentage of power in comparison with the four-stroke-cycle, since about 15 per cent. of the stroke is lost, due to the uncovering of the exhaust ports.

From low-spring indicator diagrams, it was found that atmospheric pressure was reached on the compression stroke when the piston had just covered the exhaust ports. The engines tested covered a variety of sizes ranging from 10 to 100 hp., and with piston speeds varying from 600 to 900 ft. per minute. It was found, however, that the variation in the piston speeds had no appreciable effect upon the compression pressures.

The relation between pressures and volumes is represented by the following:

$$P V^n = P_1 V_1^n \text{ or } \frac{P}{P_1} = \left(\frac{V_1}{V}\right)^n$$

where,

$P_1 = 14.7$;
P = Compression pressure absolute;
V = Clearance volume;
V_1 = Total volume.

The accompanying table shows the results obtained

VALUES FOR P and n for DIFFERENT ENGINES

Bore	Stroke	Compression Pressure Lb. per Sq.In. P	Value of Exponent n
9	12	105	1.27
10	15	98	1.33
10	15	110	1.29
10	15	134	1.32
10	15	170	1.31
11	16	115	1.29
11½	16	108	1.26
14	16	118	1.35
14	18	126	1.32
14	18	134	1.35
14	18	144	1.32
16	24	155	1.37

from these tests, giving the bores and strokes of the engine, together with the compression pressure, also the value of the exponent n in the above equation. It will be noticed that these values vary from 1.26 to 1.37, the average being close to 1.33. From the tests it would seem safe to accept the value of 1.33 for compression calculations in this type of engine. This value, which is equivalent to 1⅓, greatly simplifies compression calculations which, at best, are somewhat difficult for the average engine designer. Tables of squares and cubes are readily obtainable, while the fourth root may be obtained by taking the square root of the square root.

As an example, assume an engine cylinder of 16-in. bore and 20-in. stroke, the distance from the end of the cylinder to the edge of the exhaust port being 85 per cent. of the stroke, or 17 in. The area of a 16-in. circle is 201.06, which, multiplied by 17, gives 3418 cu.in. as the effective piston displacement. It is desired to carry a compression pressure of 135 lb. gage, which would make the absolute pressure 149.7 lb., while the pressure at the beginning of the stroke is 14.7 lb.

We now have:

$$P_1 = 14.7 ; P = 14.7 + 135 = 149.7$$

$$\frac{P}{P_1} = \frac{149.7}{14.7} = 10.18$$

$$V_1 = 3418 + V$$

Now,

$$\frac{V_1}{V} = \sqrt[n]{\frac{P}{P_1}}$$

or

$$\frac{3418 + V}{V} = \sqrt[4]{(10.18)^3} = 5.69$$

$$(5.69 - 1)\,V = 3418$$

or

$$V = \frac{3418}{4.69} = 728 \textit{ cu.in.}$$

as the volume of the compression space.

The accompanying curve shows graphically the relation between the pressure and volume ratios. Compression pressures are given at the bottom, since it may be safely assumed that the pressure at the beginning of the compression stroke is atmospheric. At the left is given both the ratio of the compression volume to the total cylinder volume, and also to the piston displacement, the latter value being one less than the former.

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Ellison Differential Draft Gage

The inclined-tube differential draft gage, first brought out by L. M. Ellison, of Chicago, in 1896, formerly was made in the open type only, but more recently an inclosed type, with a glass cover to show the scale and the inclined tube in which oil is used as the indicating medium, has been added to the line. The liquid movement is

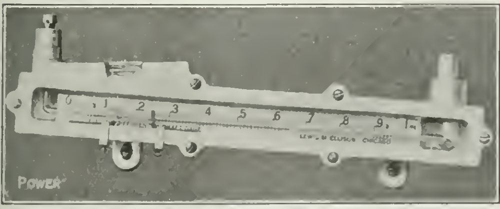

FIG. 1. COVER-TYPE DIFFERENTIAL DRAFT GAGE

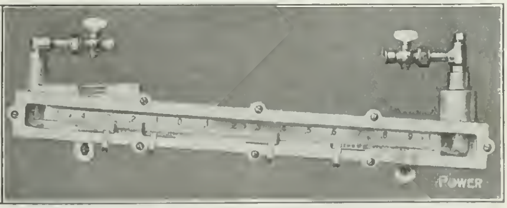

FIG. 2. COMPOUND DIFFERENTIAL DRAFT GAGE

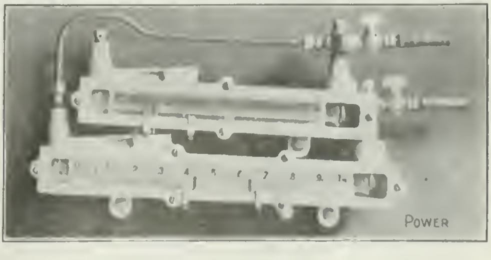

FIG. 3. MULTIPLE DIFFERENTIAL DRAFT GAGE

multiplied five, ten or fifteen times. The 1914 model. Fig. 1, is of heavy construction and as an innovation has a pair of movable pointers, which are attached to the cover frame and may be set to indicate an economical range of draft for given variations in load and fuel bed.

Fig. 2 shows a new single-tube compound gage which multiplies the liquid movement ten times. The scale reads on both sides of zero, on the chamber end indicating the draft at the breeching, or indirectly variations in the air supply, and at the indicating-tube end of the gage the draft at the furnace. When both cocks are closed, the two tube ends are vented to the atmosphere through openings in the cocks, and the liquid stands at zero. To indicate the furnace draft only, the cock at the indicating-tube end is opened, and the cock at the other end for the draft at the breeching; as with a single tube only one reading at a time can be taken. It is usual to run the gage continuously on the chamber end, which is connected to the breeching, and use the draft or furnace side only as a check in case of soot stoppage. Pointers limiting the economical range for either reading are provided.

A third gage, which has just been perfected, is the multiple differential gage shown in Fig. 3. This consists of two cover-type gages mounted on a cast-iron plate and cross-connected with copper tubing. The upper gage continuously indicates the furnace draft, and the lower gage the variations in the air supply by the drop in pressure between the flue and the furnace. As the gages are independent of each other, they can be equipped with scales which magnify equally the liquid movement, or one may magnify ten and the other fifteen times. For light draft and low drop, such as is found in oil burning, the larger scale is of special advantage. The several types mentioned and other gages modified for special work can be furnished either "right or left" by Lewis M. Ellison, 6238 Princeton Ave., Chicago, Ill.

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Portable Dead-Weight Tester

The accompanying illustrations represent a new portable device for testing pressure gages by dead weight. Differential pistons have been utilized to create a hydraulic multiplication, and friction between the parts has been minimized. The gage to be tested need not be removed from its working position after putting in the tee below the gage, Fig. 1. This instrument may be used with or without tubing and tripod to reach an elevated gage or as a bench machine without a tripod. The oil used to transmit pressure to the gage also serves to keep the working parts lubricated.

The design is based on the fact that the pressure applied to the surface of a fluid is transmitted to every part of it. Referring to Fig. 2, the area *B* is an exact multiple of the area *A*. If the area *B*, for example, is 20 times that of *A*, and a one-pound weight is placed on the tray of the piston *D*, its pressure is transmitted undi-

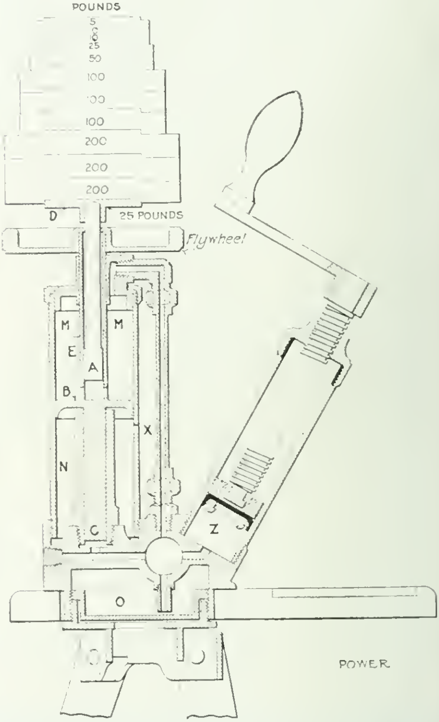

Fig. 2. Section through Portable Dead-Weight Tester

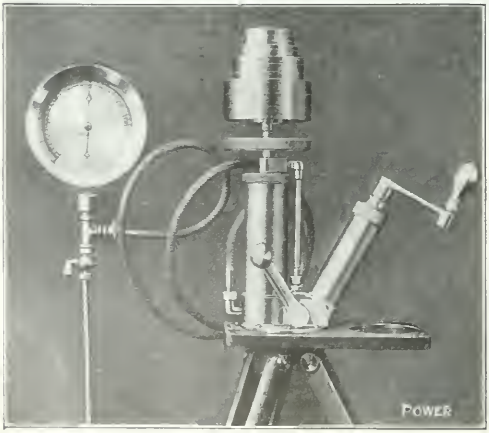

Fig. 1. Tester Connected to Gage

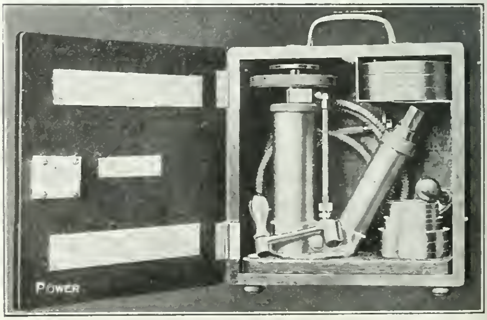

Fig. 3. Tester in Case

minished to each surface unit of area B. In other words, the area B is exerting a pressure of 20 lb. on the area C. For example, let the area C be $\frac{1}{5}$ sq.in. Hence the weight registered by the gage is $20 \times 1 \times 5$ or 100 lb. per sq.in. In the same way the proportions of the plungers have been worked out to read pressure in kilograms per square centimeter. Decreasing either or both of the areas A and C, B remaining constant (for manufacturing purposes), the gage reading increases. If A and C increase, the pressure under C decreases.

As the weight employed is multiplied from 1 to 500 times, according to the capacity of the machine, so likewise the retarding effect of the friction would be multiplied. This serious obstacle has been overcome by the attachment of the flywheel to the piston E. The inertia of the floating weights allows the piston E to rotate around the piston D free from the effect of friction. The flywheel, carrying with it the piston E, eliminates the effect of friction within the cylinder, thus allowing the weights employed to give their true multiplied weight. The weight of the pistons is regulated in different instruments to give a reading of an even five on the gage for convenience. This is known as the initial constant and in high-capacity instruments is 25 lb. Therefore, when the weights, 1000 lb., are placed on the tray, the gage, if correct, should read 1025 lb. If it fails to register according to the weights used plus the initial, the error is at once evident. The constant value of a dead-weight test makes it the only true test.

This instrument is initially filled by immersing the tube in a vessel of oil and unscrewing the handle shown at the left of Fig. 2. This fills the oil cylinder Z, after which it is conveyed to the gage when attached and below the areas A and C. The direction of flow is controlled by the three-way cock, the handle of which stands at the front of Fig. 1. When the test has been made, the oil is stored for the next test in the reservoirs N and O, which are connected by a duct, and to the reservoir M, if desired. Air compression below the area B is eliminated by the hole X.

This equipment may be packed in a case, Fig. 3, its weight being but 17 lb. for tests from 1000 to 5000 lb. and as low as 13 for tests to 500 lb. Heretofore, 200 lb. dead weight has been necessary on the ordinary $\frac{1}{5}$-sq.in. tester to make a test to only 1000 lb.

This instrument was invented by Richard C. Cox, Cambridge, Mass., and is manufactured by the Simplex Tester Co., Brattle Building, Harvard Square, Cambridge, Mass.

*

Difficulties in Transportation

From the accompanying illustrations a good idea may be had of some of the transportation difficulties encountered in Australia. Figs. 1 and 2 show a heavy boiler being drawn over a sandy country road in Victoria, Australia, on the way to a mining plant. The boiler weighs slightly over 18 tons, and is being hauled by a bullock team.

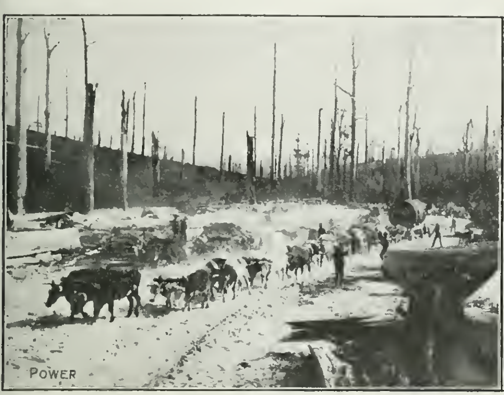

Fig. 1. A Sandy Road

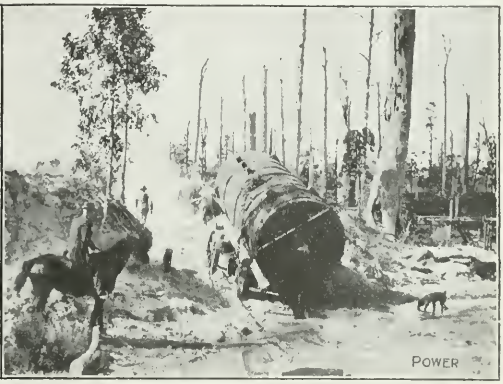

Fig. 2. A Hard Haul

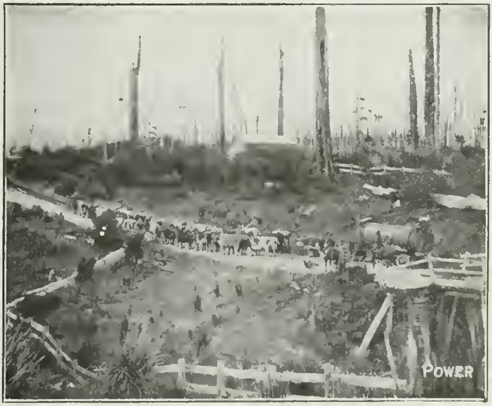

Fig. 3. Safely over the Bridge.

One peculiarity is that the wagon has six wheels. The extra wheels were necessary to carry the heavy weight, this vehicle at ordinary times being used for handling timber. Fig. 1 shows the team at work, and Fig. 2 is a view of the boiler being hauled up a small sand hill.

The photographs give a good idea of the tin-producing country in Australia, where the trees have been ringed and left standing dead, a ring of bark being removed near the base to kill the tree.

Fig. 3 shows a large surface condenser which has safely crossed a crudely constructed bridge.

Animal and Vegetable Oils; Their Preparation and Uses*

By R. C. Griffin

SYNOPSIS—The most valuable vegetable oils include linseed, china wood, cottonseed and olive oils. The fish oils are menhaden, seal, whale and sperm oils. The animal oils are neatsfoot, lard and tallow. Nearly all were formerly used for lubricating purposes, but now have mostly given way to mineral oils. The processes of obtaining these oils and the methods of detecting adulterations are described.

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Animal and vegetable oils are often called "fixed oils," because in contradistinction to mineral oils they cannot be volatilized or distilled without decomposition. Chemically speaking, they are all glycerides of fatty acids. The gylcerides are neutral substances, whereas the fatty acids are, as the name implies, of an acid nature. A simple differentiation for the layman between neutral oils and fatty acids is this: When treated with caustic alkalies they both form soaps and a secondary product; but in the case of the glycerides this secondary product is glycerin, whereas in the case of fatty acids it is simply water. All acids, whether of a fatty or of a mineral nature, such as muriatic acid, when neutralized with caustic alkali, form water as a secondary product. All glycerides when so neutralized form glycerin.

The animal oils are obtained by merely heating the fatty tissues of the carcass; that is, by "rendering" or "trying out" the fat, or by boiling out the fatty oil with water. Vegetable oils occur mostly in the seeds or fruit of plants and are obtained either by pressing or by extracting with solvents. Since each of the oil-yielding plants and animals produces its characteristic oil, there are very many varieties of fixed oils. Animal oils are, as a rule, either nearly colorless or yellow; vegetable oils occur in various shades of yellow and green. Each variety generally has a distinctive odor. Their specific gravities (weight in comparison with an equal volume of water) vary from about 0.880 to 0.970 (water = 1.000).

Sperm oil is the lightest and the most fluid and castor oil the heaviest and the most viscous of the fixed oils. Certain of the vegetable oils, when exposed to the air, rapidly absorb considerable oxygen, forming thin, elastic, varnish-like films. Such oils are called drying oils, of which the best known is linseed oil, largely used in paints. Other vegetable oils show no tendency to form such films and these are called nondrying oils. There is also a third class of oils, called semidrying, which falls between the drying and the nondrying classes. For lubrication, either nondrying or semidrying oils must be used, such as olive, rape and castor oils. It is important, moreover, that all oils used for lubrication should be as free as possible from fatty acids. All fixed oils contain a certain amount of fatty acids, some more than others; and if the oil is allowed to stand in the air the amount increases and becomes "rancid." No oil which contains more than 4 or 5 per cent. of fatty acid should be used to lubricate any kind of machinery (we do not include here cutting oils). For delicate and intricate machinery the amount permissible is considerably less. The fatty acids not only attack and corrode metal, especially if it is brass, but at the same time form soaps which dissolve in the oil and cause it to get thick and gummy.

The animal oils most valuable for lubrication are lard, neatsfoot, tallow, whale, sperm and porpoise oils. Formerly these oils were widely used for lubricating purposes, but now they have given way to mineral oils. They still have other important uses, however.

Linseed Oil

Linseed is perhaps the most widely known of the drying oils. This class cannot be used as lubricants. The chief interest in linseed oil is its use in paints. It is obtained from the seeds of the flax plant and considerable quantities are produced in this country. The seeds are generally crushed between rollers and then heated in a mixing kettle and finally pressed while still warm.

Linseed, like all expensive oils, is often adulterated with cheaper oils, but it is difficult to detect such adulterations except by chemical analysis. Fish oils are known by the odor of the cold oil. Linseed oil itself when heated has a fishy odor. A good oil for paints should be clear, have a pleasant, clean odor, and should not separate gelatinous matter when heated. A "raw oil" when flowed over a clean piece of glass and allowed to stand in a vertical position should dry hard and free from stickiness within 75 hr., and a "boiled oil" within 24 hr. Its specific gravity is about 0.93.

China-Wood Oil

This oil, also called Japanese-wood and tung oil, is obtained from the seeds of a tree native to China and Japan. These trees produce nuts having three seeds each, and the oil is obtained by cold pressing the seeds.

It has a rather pale-yellow color and a characteristic and somewhat unpleasant odor. The Chinese oil has a specific gravity of about 0.941 and the Japanese about 0.933. The only heavier fixed oil is castor oil. A characteristic property of the oil is its forming a jelly when heated to 250 deg. C., or even when kept at 180 for an hour or two. The oil will also become solid if long exposed to the light. Apparently, China-wood oil is not extensively adulterated.

Soja-Bean Oil

This oil, also known as soy-bean oil, Chinese-bean oil, and simply "bean oil," is obtained from the seeds of a plant which grows largely in Japan, Korea and China. The soja-bean industry is one of the staples of Manchuria and Japan. The oil is largely used there for edible purposes, but it has recently been finding use in this country as a paint and varnish oil in connection with linseed; it has about the same specific gravity as the latter, but its drying properties are considerably inferior. It belongs to the class of semidryng oils.

Cottonseed Oil

Cottonseed oil, as its name indicates, is obtained from the seeds of the various kinds of cotton plants, and is produced in large quantities in this country. It is obtained from the seeds by pressing, and is suitable for edible purposes. There seems to be a prejudice against using it under its own name. Many people prefer to buy "table oil," "salad oil," "butter oil," or "sweet nut oil," and would be probably quite surprised to know that such names are generally merely aliases for cottonseed oil.

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*Abstract from the "American Machinist," Feb. 5, 1914.

The specific gravity is 0.925 and can be raised by treatment to about 0.94. On account of its drying properties and its tendencies to gum, it cannot be recommended as a lubricant. Its chief legitimate uses are for edible purposes and for soap making.

RAPE OIL

This oil is also known as colza oil and is obtained from rape seed: it is clear, pale yellow, having a characteristic odor. Its specific gravity is about 0.914, and its viscosity is higher than any other fixed oil except castor oil—that is, only one other fixed oil will flow more slowly at any given temperature. This oil is semidrying and, therefore, it is not suitable as a lubricant for certain classes of machinery; its chief use is for burning.

Rape oil is often adulterated with other oils, such as cottonseed, corn, linseed, fish and mineral oils. The presence of fish oil can sometimes be detected by the odor, especially if the oil is warmed, and mineral oil is often shown by the "bloom" or fluorescence which it imparts. The other oils can be detected only by chemical analysis.

OLIVE OIL

This oil, as its name indicates, is obtained from the fruit of the olive tree. The finest edible oils, which are often called "sweet oil," are obtained from hand-picked olives, which are carefully crushed in a mill without breaking the pits. The meat is separated from the pits and pressed in a hydraulic press. A second grade of oil is then obtained by pouring cold water over the pressed meats and again pressing. This pulp is once more removed from the press, mixed with hot water and pressed, yielding the bright colored oils which are used for technical purposes, burning oils, lubrication and soap making.

The specific gravity of the oil is about 0.915. It is a nondrying oil, and formerly found considerable use as a lubricant for light machinery. The better grades are now too expensive for this purpose, however, and the cheap grades generally contain so much fatty acid that they are likely to cause trouble by the formation of gummy deposits. The oil is not at present much used for lubrication, although it is still employed, mixed with mineral oil, on spindles and looms. Many adulterants are used in connection with olive oil, especially cottonseed oil.

CASTOR OIL

Castor oil is obtained from the seeds of the ricinus plant, which grows in great quantities in all tropical countries. There are many cultivated varieties and the seeds, known as castor beans, vary considerably in size and appearance. The United States, particularly certain of the Middle West states, grows many castor beans, but the greater amount produced, however, is from imported beans, most of which comes from East India. The oil is obtained from the beans either by pressing or by extracting with solvents. A noteworthy peculiarity is that it contains a poisonous alkaloid known as ricine. It requires care to get the oil out of the beans without getting any of the poisonous ricine with it. Only the purest and most carefully prepared castor oil can be used for medicinal purposes.

For obtaining the best quality (medicinal) oils the beans are first passed through specially made rollers which crack the outside husks, or shells, which are then removed by a blast of air. The inner kernels are then pressed cold and part of the oil is squeezed from them. Only the cold-pressed oil can be used for medicinal purposes, since the ricine does not pass into the oil.

The crude oil obtained is refined by steaming and then filtering. When properly refined the oil keeps well and is not likely to turn rancid. It is nearly colorless or pale greenish yellow, and the taste is mild at first, then harsh; being more marked in American oils. The oil has the highest specific gravity of all the fixed oils (generally about 0.965), and it is also most viscous of them all. It does not begin to congeal until about 0 deg. F. Castor oil is completely soluble in about three to five times its volume of grain alcohol at 60 deg. F. If castor oil when mixed with three to five times its volume of alcohol does not give a clear solution, it is probably adulterated.

Castor oil is nondrying, and is, therefore, suitable for use in lubrication; generally it is comparatively free from fatty acids. It is, however, too viscous for most lubricating purposes, and is mostly used in a mixture. For heavy and quick-running bearings where considerable heat and friction are developed, it has been used with some success. Castor oil is also used as a belt dressing or preservative.

MENHADEN AND OTHER FISH OILS

Real menhaden oil is an American product obtained from the menhadden, a fish a little larger than the herring. The term "menhaden oil," however, is rather elastic, and oils obtained from other species are often sold under that name. The fish are placed in large pans, where they are boiled with steam. This disintegrates the flesh, and, after standing some time, the oil rises to the top and is skimmed off.

The color of the oil varies widely, depending on the freshness of the fish from which it was extracted and upon the length of boiling. The specific gravity of the oil is about 0.93.

The process of obtaining oils from other fish is similar to the above.

The principal use of menhaden oil is in the leather industries. In the machine shop it finds an important use as a quenching and tempering oil.

SEAL OIL

Seal oil comes from the blubber of seals. In the good old days the oil was tried out of the fat right on board the vessel. Later, however, the seals were brought to special rendering plants on shore.

At the present time seal oil is obtained in a manner similar to the process used for whale oil. The blubber is carefully separated from the flesh, cut into strips, chopped up fine, placed in large pans and boiled with steam. The specific gravity is about 0.925. The best qualities are largely used as burning oils.

It is also used to some extent as a lubricant for screw cutting machines, either alone, or mixed with mineral oil. It is similar to whale oil, and the latter is often adulterated with it. Both seal and whale oil are used in tempering steel.

WHALE OIL ("TRAIN OIL")

True whale oil comes from the Arctic or Greenland right whale, but the so called "whale oil" of commerce is obtained from the blubber of various species of whales. Its history is almost exactly that of seal oil. Much of the American oil, however, is still tried out on board the whaling vessels, which deliver the crude oil to the refineries on the coast. A large right whale of the Pacific, or a full grown bowhead whale will sometimes yield as much as 7800 gal. of oil. The small white whale, on the other hand, will only yield from 30 to 100 gal. The right whale oil is of better quality than the Southern whale oil, which in turn is better than that from the finback whale.

The best quality of oil is obtained as "first runnings" from the separated blubber in the trying-out process.

Whale oil is somewhat similar in its appearance and fishy odor to sperm oil, but can be easily distinguished from it by its specific gravity, which is above 0.92, whereas that of sperm oil generally varies between 0.86 and 0.88. Even the best qualities have marked drying properties and it can, therefore, be used as a lubricant only for rough work. It is considerably employed, however, for mixing with mineral oil both for lubricating and as a cutting oil.

Since whale oil is a cheap oil, the only adulterants generally employed are still cheaper oils, such as rosin, mineral, cheap fish and sometimes seal oils. The rosin, and mineral oils are easy to detect, but the fish oils are difficult of detection, and it is impossible to detect seal oil by chemical means.

SPERM OIL

True sperm oil is obtained from the blubber and the head of the great sperm whale. A single male sperm whale will yield on the average from 2300 to 2800 gal. of oil. Arctic sperm oil comes from the smaller bottlenose whale, which is mainly found in the Arctic Seas, and yields about 250 gal. per whale. The two oils, however, are very similar.

The process of obtaining the crude oil is similar to the old process of trying out whale oil. It is practically all done aboard ship.

The true sperm oil, refined, is pale yellow and the best grades have only a faint odor. Bottlenose oil is usually darker and has a rather unpleasant fishy odor. Both oils are much more fluid than most animal or vegetable oils. On the other hand, when heated, their fluidity does not increase as rapidly as in the case of other fixed oils. This property of retaining its viscosity, with rising temperature, makes sperm oil valuable as a lubricant for light machinery and spindles, but it cannot be used for heavy work. Another property is that it has little tendency to become gummy or rancid. Bottlenose oil, however, shows more of this tendency, and is, therefore, less valuable. It is hard to distinguish these two oils apart, since there has appeared on the market a pale-colored "deodorized" sperm oil. The specific gravity is low, being only about 0.88. This makes it difficult to adulterate it with other fixed oils without detection.

NEATSFOOT OIL

In theory neatsfoot oil is obtained by boiling out the feet of cattle in water, but in practice the commercial oil may include that from the feet of horses, sheep, swine and other animals. Some dealers ease their consciences by calling such oils "foot oil." The oil is generally a by-product of packing and slaughtering houses. In preparing it, the feet (after washing free from blood and dirt) are scalded with boiling water for 10 to 15 min. to loosen the hoof, which is then pulled out. The rest is boiled out in water for 8 to 10 hr. The bulk of the oil is skimmed off from time to time, poured through a screen, separated as much as possible from the water, dried by steam pipes, and finally filtered.

If properly prepared from fresh material the amount of fatty acid in neatsfoot oil is generally less than ½ per cent., but the oil ordinarily met with contains sometimes as much as 25 to 30 per cent. The chief factors in determining the value of a given sample are color, odor, low freezing point, or "cold test," and freedom from fatty acids. It should not be used for lubricating purposes if it contains over 1 per cent. of fatty acids.

Neatsfoot is pale yellow, and rather thin, with a specific gravity of about 0.915. Its odor depends upon the care with which it has been prepared and is sometimes very rank. On standing it deposits light-colored "stearine" or fat, sometimes in considerable amounts. On account of its high cost the oil is frequently adulterated. For this purpose vegetable oils are largely used, such as rape and cottonseed oil. Fish, mineral and rosin oils are also used. The odor and appearance will sometimes indicate whether an oil is adulterated, but generally adulterants can be detected only by chemical tests.

By far the greatest use of neatsfoot oil is in the leather industries, and as a belt dressing, either alone or mixed with other materials. It is a valuable lubricating oil for clocks and delicate machinery. Its main use as a lubricant at present, however, is, like tallow and lard oils, for mixing with mineral oils. It is pretty expensive to use alone, but forms with mineral oil a valuable lubricant. For this purpose, care should be taken to use only those oils with as little fatty acid as possible.

LARD OIL

Lard oil is a secondary product from the manufacture of lard and may be looked upon as the liquid part of the latter. It is obtained by allowing lard to crystallize at a carefully regulated temperature, and then separating the liquid and solid portions by straining under pressure. Just as the quality of lard varies largely with its source and the condition of the hogs, so lard oil varies in quality according to the lard from which it is obtained. Somewhat lower grades are used for burning and as lubricating oils.

The amount of fatty acid present in different specimens also varies greatly. This may be looked upon as an indication of the freshness of the oil and also of the care with which it was prepared. An oil which is practically neutral will become rancid on standing, especially if exposed to the air. The specific gravity of lard oil is about 0.915. Its color varies from practically water white to dark brown, depending upon the grade. Because of its high price, lard oil is frequently adulterated with mineral and cheap vegetable oils, and also to some extent with fish and blubber oils. Any considerable amount of the latter can be generally detected by their fishy odor. There are so called "mineral lard oils" which are mixtures of mineral and lard oils. In such oils the odor of mineral oil is generally quite pronounced and they are usually thinner than lard oil and the surface has a different color to the body of the oil, due to the peculiar behavior of mineral oils toward reflected light. Oil men speak of this peculiarity as "bloom."

TALLOW AND TALLOW OIL

The term tallow is applied to the fat of certain ruminant animals. Beef tallow is obtained from cattle; mutton tallow from sheep and goats. The operation of melting out the fat from the enveloped tissues and membrane is generally carried out in large kettles by means of live steam. Tallow at from 60 to 80 deg. F. is a mixture of solid and fluid fats. If subjected to pressure the fluid portion can then be separated out and is known as tallow oil.

Beef and mutton tallow are quite similar in their general characteristics. For most commercial purposes "tallow" may be either one or a mixture of both. Its chief interest in the power plant, however, is as a lubricant grease. Formerly it was used alone, but now its main use is in mixed greases, although it is sometimes used unmixed for lubricating heavy engine bearings, such as in rolling mills. It should be white in color and when melted should be clear and free from more than a slight amount of suspended particles. It should also have a fresh, clean odor, and be as free as possible from fatty acids. In freshly rendered tallow the amount of fatty acids is seldom over ½ per cent., but in commercial samples it may be as much as 25 per cent., or even more. Such rancid tallows should not be used for lubrication, since the fatty acids will attack and corrode metal. The upper limit should be not over 4 per cent. Beef tallow is less likely to become rancid on standing than mutton tallow.

Tallow oil is the liquid part of tallow, just as lard oil is the liquid part of lard. It is made by melting tallow and keeping it warm for several hours. Much of the stearine crystallizes and is removed by hydraulic pressure in canvas bags. If tallow oil is properly prepared, the amount of fatty acid is low. This makes it especially valuable for making compounded cylinder oils from mineral-oil stock. Such mixtures seem to have a greater "oiliness" than mineral oil alone. It is a lubricating oil for shaftings and heavy bearings, either alone or mixed with mineral oil. Care should be taken that the tallow oil is fresh and as free as possible from fatty acids, especially when used in cylinder oils. It should have a clean, sweet odor, and be pale yellow, or nearly colorless and free from suspended matter. It is seldom adulterated. Its specific gravity ranges from 0.911 to 0.915, and it flashes at between 175 to 500 deg. F.

ROSIN OIL

Rosin oil is the principal product of the destructive distillation of colophony (common rosin). When we heat water it vaporizes into steam, and if this steam is condensed we get water back again unchanged. That is a process of plain distillation. When, however, we heat rosin, we also get vapors; but if they are condensed, we do not find the product is rosin again, but entirely different substances, the chief of which is rosin oil. The distillation breaks up the rosin chemically and destroys its original nature, hence it is called "destructive distillation." The process is carried out in cast-iron stills, which hold charges of from three to five tons, and are heated from beneath by a direct flame. The rosin oil distills over at above 570 deg. F., and if the distillation is carried clear to dryness, the amount of oil may be as high as 85 per cent. The residue in the still is rosin pitch, or in case the distillation is carried to completion, it becomes coke.

Crude rosin oil is a brown, viscous liquid with a characteristic odor and a marked "bloom," usually of a bluish or violet tinge. When heated to about 300 deg. F. for three or four hours, it loses from 1 to 5 per cent. of its more volatile constituents and assumes a green fluorescence. This fluorescence can be destroyed by chemical means, and by a process of refining the color can be made a pale brownish yellow. The specific gravity of the commercial oils generally ranges from 0.96 to 0.99, but not infrequently they run as high as 1.01. This latter case is interesting because it means that an oil of this specific gravity is heavier than water and will sink when brought in contact with water. A common use of rosin oil is in the manufacture of belt dressings.

Rosin oil is not suitable for lubricating machinery, but is often used in adulterating mineral and other lubricating oils. It can often be detected in such cases by its odor, which is almost unmistakable to one familiar with it.

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Automatic Sampling of Coal

By L. C. Bosler

A great deal has been written and many discussions have taken place regarding the proper methods to em-

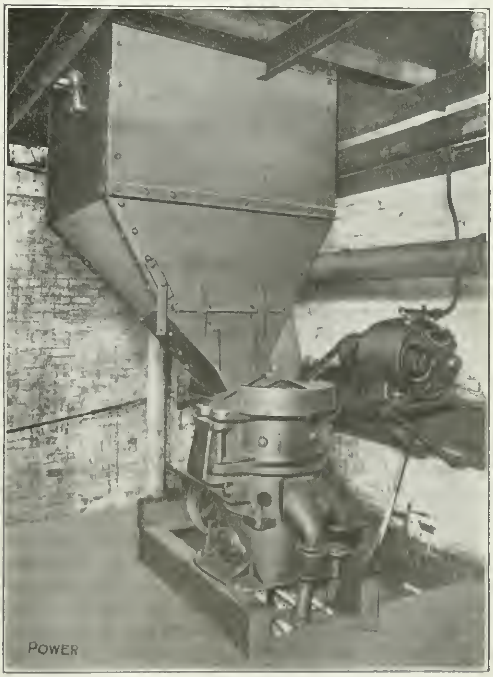


FIG. 1. AUTOMATIC COAL SAMPLER UNDER COAL CONVEYOR

ploy to correctly sample coal. It seems strange to the writer that some of the larger consumers of coal should continue to use the ancient and crude system of sampling coal by taking a handful or shovelful from each car or bucket unloaded, as the case may be. For a proper analysis of a quantity of coal the first and important thing to get is a representative sample, after which this can be reduced to a working quantity by an automatic machine.

The Philadelphia Rapid Transit Co., has perfected and put in its Beach power station an automatic coal-sampling device by which all of the coal received is sampled without the human element entering into the operation at all.

Coal is received in boats and is unloaded therefrom by two electrically driven locomotive cranes on the pier. The coal is dumped into cars where it is weighed and is then delivered to a conveyor and carried to the crusher. The coal at this point is reduced to a size not greater than 3 in. in diameter. It is then raised to a height equal to the elevation of the top of the coal bunkers and is then conveyed to them. The sampling device is in this last named conveyor.

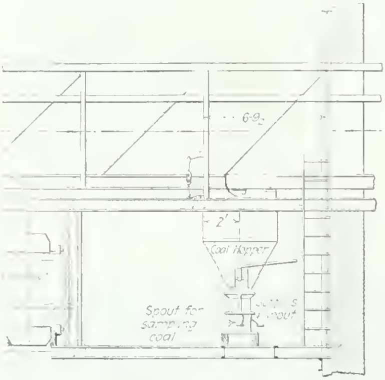


FIG. 2. CONVEYING AND SAMPLING MACHINE

Referring to Fig. 2, the hopper for catching the major sample is underneath. Beneath this is a No. 00 rotary crusher and automatic sampler, made by the Sturtevant Mill Co., which receives the coal from the hopper. This machine performs two separate and distinct functions: it first grinds the major sample to any desired size and then divides it into two parts, one of which is the final sample, it being drawn from the front spout, while the balance falls back into the bunker through the side spout. By operating the adjusting wheel on the grinder, any proportion desired can be obtained between the final and the major sample.

Fig. 3 is a view of the gate-operating mechanism. On a flight of the conveyor is fastened a plate A. With the movement of the conveyor to the left this plate engages with the roller B and thereby raises the arm C. With this movement the arm D is also raised as both are keyed to the shaft E. As the arm D raises it pulls up the arm F, which, through the shaft G, is keyed to the arm H. At the end of this arm is fastened the rod J, which operates the gate. This gate is closed by the use of a counter-weight attached to the arm F. By the pull rod K, and yoke lever L, the arm C can be slid on the shaft E out of the path of the plate A, thereby cutting the apparatus out of service.

It will be seen that there must be a fixed relation between the position of the flight and the opening of the gate. With the gate wide open when the flight reaches the near side of the hole, the maximum discharge will take place as the coal is always banked against the flight.

The amount of coal desired in the major sample is governed by the number of openings of the gate per revolution of the conveyor and this in turn by the number of arms A that are fastened to the flights.

As an example, from each boat load, averaging 800 tons, a major sample of about 1500 lb. is taken. After passing the grinder and sampling machine the final sample is 6 lb.

In Fig. 1 the actual apparatus is shown under the coal conveyor in the boiler room. The two spouts referred to in the foregoing are seen near the bottom of the grinder.

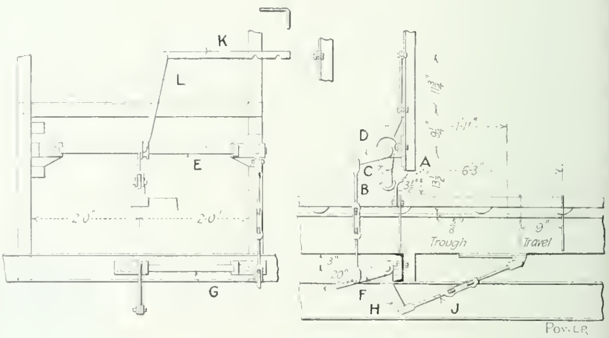


FIG. 3. GATE-OPERATING MECHANISM

During the recent special tests made by the company on six samples of 1000 tons each, three major samples of 1500 lb. were desired from each cargo. To accomplish this, it was necessary to have four gate openings per revolution of the conveyor, this delivering the required amount. The opening in the bottom of the conveyor trough through which the coal passes to the hopper is 4x6 in. and by actual experiment was found to deliver 3 lb. of coal per opening under ordinary conditions of moisture.

All of the apparatus except the crusher was designed and erected by the company's engineers and has been in continuous service for a year, giving excellent results.

⁂

Discharge From Traps—Steam traps should not discharge along the foundation walls of the boiler house or of any other building. The continued discharge from these traps will in time effect the settlement of the building's walls. Where the condensation is needed as make-up water it should be discharged to the feed-water heater or direct to the boiler by any of the approved methods. The drips from exhaust heads are often allowed to drain directly on the roof of the boiler house, and thence to the sewer by way of a rain-water conductor. This is bad practice, as the hot water will damage any roof of modern construction, such as a roof of tar and gravel composition.

Electrical Kinks for the Operating Man

By H. Winfield Secor

The operating engineer is often required to make a few rough tests on electrical machinery about the plant, and particularly on motor and dynamo armatures. It is well to know a few simple testing schemes, so that armatures can be tested without any elaborate apparatus, and a few methods which have been extensively adopted in practice are mentioned here.

In Fig. 1 is indicated a common shop method of testing out direct-current armatures of the lap- or wave-wound types. Current is passed through the armature by way of the brushes or, if the armature is not in place, at points corresponding to the usual brush positions on the commutator. which can be effected by tying the two test leads T and T_1 on the commutator by means of a piece of string. A milli-voltmeter, or ammeter without a shunt, is connected across two adjacent commutator bars as shown. A simple testing handle fitted with two nail prongs, as at B, Fig. 1, is handy in making such a test, and a bank of several 110-volt lamps (or 220-volt lamps on a 220-volt circuit) is used for limiting the current passed through the armature under test.

The current through the armature should be regulated until a suitable arbitrary reading is had on the milli-voltmeter, and the readings across any two adjacent bars will be approximately the same, if the armature is in proper condition. After making a test across the various pairs of segments between the leads T and T_1, these should be shifted, keeping them the same distance apart and repeating the bar to bar test until the whole commutator has been tested. This is the usual shop test on armatures newly wound, or where the winding or commutator connections have been repaired. If a higher meter deflection than usual is observed, a loose or wrong connection of the armature coils may be looked for. If the meter needle goes off the scale there is probably an open coil in the winding at the point under immediate test. Where a reading lower than normal occurs, a short-circuit, perhaps in the turns of the coil but frequently between the commutator bars, where the leads have been soldered to it, will be found. It is usual to test the insulation resistance of the armature winding from the steel shaft and core by connecting the milli-voltmeter between one testing lead, say T_1, and the shaft, while the other testing lead T is left connected to the commutator. Practically no deflection should be observed.

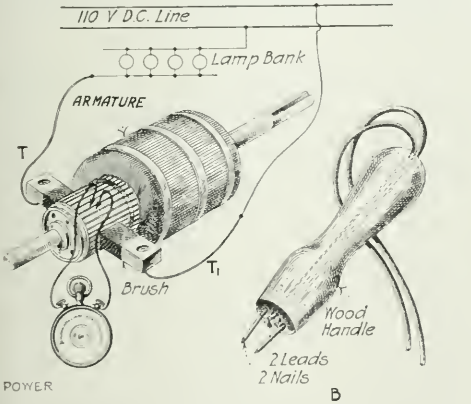


Fig. 1. Testing Out Armatures by Means of Direct Current

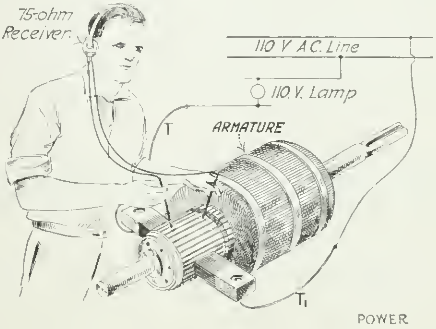


Fig. 2. Testing Out Armatures by Means of Alternating Current

In Fig. 2 is shown a test similar to that just described, except that an alternating-current circuit is utilized. A 110-volt lamp is connected in series with the test circuit, but instead of using a voltmeter for the bar to bar test, a common telephone receiver is employed. After the strength of the hum has been noted for several coils, trouble can soon be located. A decreased hum indicates a partial or completely short-circuited coil, and the commutator connections should be carefully examined. Sometimes where a coil lead passes over the turns of a neighboring coil, the insulation will be found to have chafed away, causing a short-circuit. Again it may be in the coil itself, and then, of course, the coil will have to be removed. An extremely loud hum in the receiver indicates an open circuit in the coil connected to the bars under test. With a little practice one can quite accurately diagnose armature trouble by this method. Resistance may be inserted in series with the receiver if the hum is too high and the lamp used should be of the same voltage as that of the testing circuit.

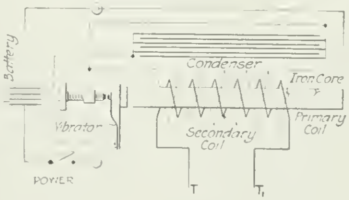


Fig. 3. Induction Coil

A substitute for the alternating-current circuit, which is not always available, is a small induction coil connected as in Fig. 3. A small tinfoil and paper condenser can be shunted across the vibrator to intensify the secondary current if desired, but if the coil is fairly strong, this will not be necessary. The secondary leads T and T_1 are connected to the commutator and used with a receiver, as in Fig. 2.

A simpler source of interrupted current is a common battery buzzer, with test leads connected across the vibrator.

A useful armature stand, two of which are required to support an armature, is shown, Fig. 4. It consists of a piece of 2 to 2½-in. iron pipe, threaded into a cast-iron flanged base having a spread of preferably about 16 to 18 in. At the top it is surmounted by a pipe flange, and a casting carrying two rollers. The latter permit of easily turning even heavy armatures, and it is convenient for overhauling and balancing them. This stand may be arranged so that the armature-bearing rollers may be raised and lowered to any desired height.

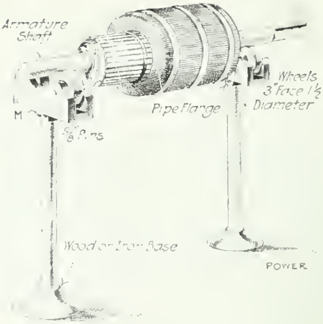


Fig. 4. Armature Stand

* *

Cutting Down the Fuel Bill

By R. M. Chargers

SYNOPSIS—Saving 35 per cent. of the coal bill in a direct-current railway plant, averaging 150,000 kw.-hr. per month.

*

In this article will be given in part the details of the operation pursued by an efficiency engineer in reducing the coal bill of a certain power plant. In this case the reduction was 35 per cent. in the cost of coal for making direct current to supply an interurban railway.

The boiler-room equipment consists of five 350-hp. water-tube boilers equipped with hand-fired stationary grates. Natural draft is furnished by two steel stacks. The coal is Georges Creek run-of-mine, one of the best grades of bituminous coal in the country, running about 14,500 B.t.u. per lb. Practically all attempts to increase efficiency were confined to the boiler room.

The plant had for years nominally operated four boilers, burned on an average about 675 tons of coal per month and turned out about 150,000 kw.-hr. in the same period. The boilers were banked from 1 to 5 a.m. The total steam per kilowatt-hour averaged close to 54 lb.

Upon being called to the property the conditions existing were not unlike those in other plants with which the writer has had to deal. The average draft over the fire was 0.5 in.; the average CO_2 content in the gases was 7.5 per cent. in the first pass and 4 per cent. in the last; the intervals between firing periods were from 40 to 50 min.; the fuel bed was carried about 18 in. thick in front of the fire doors and from 5 to 10 in. on the rear of the grates; the dampers could be operated rather crudely from the rear of the boilers; the settings were leaky, especially around the doors and drums.

The operating force never had any instruments for testing at its disposal, or been instructed along the lines of efficient boiler-room operation. It was necessary to show that these conditions were not good practice and that considerable coal could be saved by slightly changing them. Of course, the usual protests were made, such as the varying load conditions, the inefficiency of the engines, poor coal, lack of help, etc.

It was finally made clear that 4 per cent. CO_2 indicated poor furnace operation, and that 0.5-in. draft was much too high for burning 7 lb. of coal per square foot of grate surface per hour. The firemen were also shown that, contrary to their former opinion, no mystery surrounded CO_2 and the theory of draft, and that it was unnecessary to understand the laws of Boyle, Charles, Gay-Lussac and Avogadro to put them into common, every-day boiler-room practice.

After interest, enthusiasm and coöperation had been aroused, the work of building up the boiler and furnace efficiency was started. All the coal was weighed, the water measured, and the steam metered—in fact, accurate data were kept on the entire plant. During the first 24 hours the firing intervals were reduced to about 30 minutes, the fires kept more even and thinner, the draft cut down to an average of 0.36 in. over the fire, the water level kept more constant, and the CO_2 in the last release averaged 7 per cent. As a result, the evaporation increased from an average of 6.75 to 7.5 lb. of water per pound of coal, bringing the boiler and furnace efficiency up to 50 per cent.

On the following day the dusting doors were made to close tightly and many of the air leaks were stopped around the drums and headers. The CO_2 ran 7.5 per cent. in the last pass and 10 per cent. in the first, showing that there was yet considerable air leakage. The intervals between firing were then cut to about 22 min., the fires kept more even and thinner, and the draft throttled down to an average of 0.20 in. over the fire. This 24-hour period showed an increase in evaporation over the previous one and the boiler and furnace efficiency was brought up to 57 per cent.

To get still better results, it was explained to the force that one boiler would have to be cut off the line to give more nearly rating on them and a slight overload during the peaks. (We had been informed that three boilers would not pull the load, especially the peak.) One boiler was taken off, however, and the peak carried with no reduction in the steam pressure; the draft being regulated to take care of the extra demand on the boilers.

To be brief, the results of the next four days increased in like proportion to those of the first two days. In the meantime, still another boiler was cut off, leaving only two fired up. On the seventh day the firing was done about every 12 to 14 min. On account of other duties, the firemen could not further reduce this interval. More air leaks were stopped and the CO_2 maintained at 10 per cent. in the last release. The draft was now about 0.14 in., the fires approximately 10 in. thick and the bare spots scarce. The results then were: Evaporation, 10.1 lb. per pound of coal; coal per kilowatt-hour, 5.4 lb.; efficiency, 69.5 per cent.; this is a reduction on coal costs alone of 40 per cent.

Since this work of several months ago, the reduction in fuel has averaged 35 per cent. With coal at $3 per ton, this means a saving in this plant of over $700 per month.

⁂

Heat-Engine Efficiency Chart

By Henry L. Thomson

The determination of thermal efficiency is usually based on the fuel consumption per brake horsepower-hour. As specific gravity and liquid measure often enter into the problem, calculation of the efficiency becomes a tedious process. However, these calculations can be readily solved by a logarithmic chart, from which the thermal efficiency can be determined from the fuel consumption, whether given in pints or pounds of fuel of any specific gravity per brake horsepower-hour or in cubic feet of gas per brake horsepower-hour.

These various classes of fuels cover the field of the sources of energy for heat engines, and include gasoline, oil, gas and producer-gas engines, steam engines of all types, and even the hot-air engine.

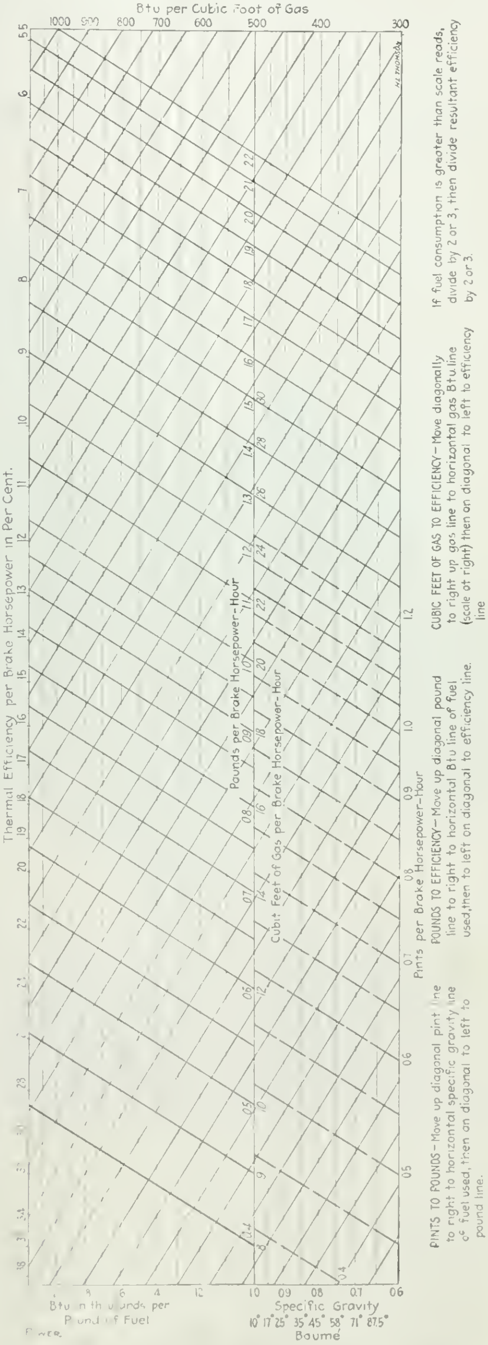
This chart will be found particularly convenient in running tests with gasoline and oil engines, with which the fuel consumption is measured in pints per brake horsepower-hour, while in the Diesel and often in the semi-Diesel type, it is measured in pounds per brake horsepower-hour.

It is always necessary in finding the thermal efficiency to know the number of British thermal units in the fuel used. This is particularly true in the case of the hot-bulb type of oil engine, which burns such a variety of fuels, with such a range in specific gravity and calorific value.

AVERAGE HEAT VALUES FOR A NUMBER OF FUELS

Fuel	Specific Gravity	B.t.u. per Lb.	B.t.u per Cu. Ft.
Gasoline	0.65-0.72	18,000	....
Naphtha	0.74	18,000	...
Kerosene	0.78-0.82	20,000 to 22,000	..
Distillate	0.80-0.90	17,000 to 20,000	
Alcohol	0.79	12,000	....
Penn. crude oil	0.92	21,000	...
Oil gas	..	....	1,000
Coal gas	...	.....	650
Water gas	...	......	630
Producer gas	...	..	110 to 150
Blast furnace gas	...	.....	100
Natural gas	...	.....	1,000
Bituminous coal	...	14,000	.
Anthracite coal	...	13,500	
Coke	...	13,500	..

As an example in the use of the chart, find the thermal efficiency of a hot-bulb engine which burns 0.7 pint of distillate per brake horsepower-hour (0.85 specific gravity, and B.t.u. 20,000). Move to the right up the diagonal line of 0.7 pint to the horizontal line of 0.85 specific gravity, then on the diagonal to the left to 0.61 pound; then to the right on the diagonal to the horizontal B.t.u. line of 20,000, and on the diagonal to the left to 20.9 per cent. thermal efficiency.



PINTS TO POUNDS—Move up diagonal pint line to right to horizontal specific gravity line of fuel used, then on diagonal to left to pound line.

POUNDS TO EFFICIENCY—Move up diagonal pound line to right to horizontal Btu line of fuel used, then to left on diagonal to efficiency line.

CUBIC FEET OF GAS TO EFFICIENCY—Move diagonally to right up gas line to horizontal gas Btu line (scale at right) then on diagonal to left to efficiency line

If fuel consumption is greater than scale reads, divide by 2 or 3, then divide resultant efficiency by 2 or 3.

Chart for Determining Efficiencies with Different Fuels

100,000,000-Gallon Centrifugal Pump for Pittsburgh[*]

By Geo. H. Gibson

SYNOPSIS—Describes the 100,000,000-gal. turbine-driven De Laval centrifugal pump for the Ross pumping station, Pittsburgh, Penn. The performance data of the pump are given.

* * *

About two years ago the water department of Pittsburgh asked for bids on a pump to be installed at the Ross pumping station to handle 100,000,000 gal. per day against a total head of 56 ft., including 18 ft. suction lift, pumping from the Allegheny River into the Aspinwall filtration plant. The pumping engines previously installed were reciprocating engines driving centrifugal pumps. However, the possibility of securing turbine-driven centrifugal pumps suggested to the engineers a careful canvas of the situation, the more so as the recent introduction of reducing gears of large capacity had for the first time made possible the combination of high-efficiency turbines with standard-speed pumps.

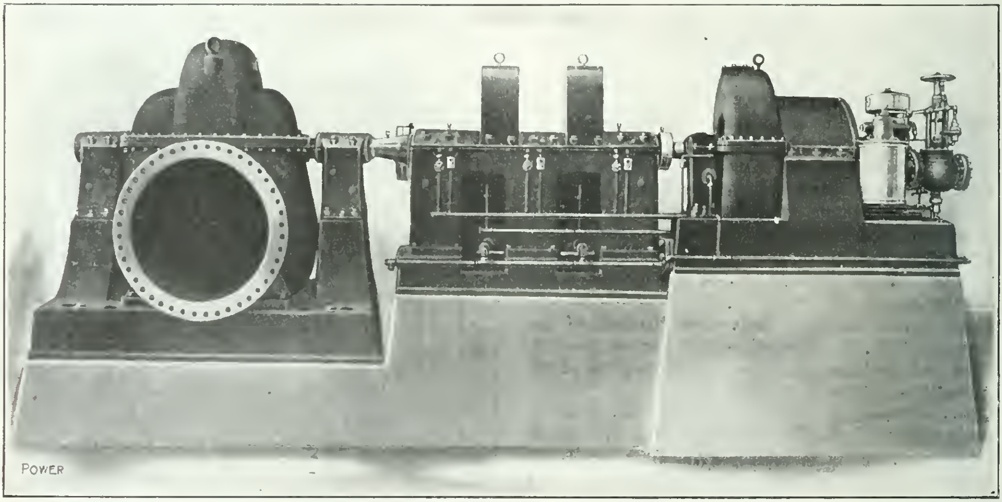


Fig. 1. The 100,000,000-Gal. Pump for Ross Pumping Station, Pittsburgh

The apparatus selected, Fig. 1, is a pressure-stage turbine driving a single-stage centrifugal pump by means of a double helical speed-reducing gear, all built by the De Laval Steam Turbine Co., of Trenton, N. J., and guaranteed to give a duty, including all steam and power used by auxiliaries, of 115,000,000 ft.-lb. per 1000 lb. of dry steam at 150 lb. pressure gage.

A ten-hour acceptance test for duty and capacity was made and readings taken every ten minutes. The steam pressure was measured above and below the governor valve by gages which were calibrated after the test, while moisture was measured by a throttling calorimeter attached immediately above the throttle valve. Vacuum measurements were made at the turbine exhaust by mercury column, and barometer readings were obtained every hour from the U. S. Weather Bureau. The condensate from the surface condenser, which included also the exhaust from the dry-air pump, was weighed in two tanks on calibrated platform scales. The discharge pressure of the pump was measured by means of a spring gage attached to the discharge pipe, close to the discharge flange of the pump. The gage was calibrated by means of a dead-weight tester. The suction lift was measured by a mercury column attached close to the suction flange of the pump, 5½ ft. below the center line. The pump as installed in the station is shown in Fig. 2.

The capacity was determined by a venturi meter of 18-in. throat diameter, the flow being indicated by a mercury manometer, the scale of which was graduated in million gallons per day. Shortly before the official test, the venturi meter was calibrated by a volumetric test of one hour's duration. While the pump was discharging into the receiving basin at the filtration bed, the elevation of the water in this basin was taken every five minutes, both by a hook gage and a Y-level, the total rise in the basin during the one hour's run being 4.55 ft. This showed that the scale furnished with the venturi manometer was slightly lower than the actual capacity obtained in the volumetric test, the average reading of the scale during one hour's run being 97,250,000 gal. per day, and the actual capacity from the rise in the basin being 98,170,787 gal. As 100,000,000 gal. per day on the scale corresponds to a reading of 21¼ in. of mercury, the coefficient of the venturi tube is 0.967, while the volumetric test gives 0.976, which would seem more likely for a venturi tube of this size.

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[*] For an analysis of the advantages of turbine-driven centrifugal pumps, see Mr. Gibson's article in the Oct. 6 issue, page 489.

The following is a summary of the principal data:

Steam pressure at throttle	151.07 lb.
Nozzle pressure	145.3 lb.
Vacuum	27.87 in.
Vaccum (corrected)	28.38 in.
Speed	344.7 r.p.m.
Capacity from venturi meter	101,650,794 gal. per 24 hr.
Capacity (corrected)	102,610,000 gal. per 24 hr.
Capacity, gal. per minute	71,260
Total head	58.713 ft.
Water hp.	1056.9
Total steam (for 10 hr. 15 min.)	179.442 lb.
Steam per hour	17,506 lb.
Duty	119,500,000 ft.-lb.
Steam per water horsepower	16.59 lb. per hr.
Electrical hp. consumed by circulating and hot well pump motors	16.26

The electrical input to the circulating pump and hotwell pump motors was measured by portable calibrated instruments. The impeller is shown in Fig. 3.

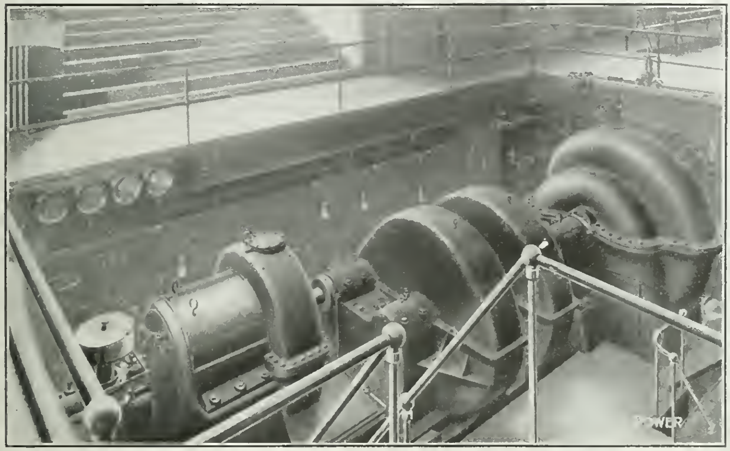


Fig. 2. View of Pump in the Station

According to the contract, the steam to be charged against the turbine for driving the auxiliaries, was to be the electrical horsepower consumed by the motors multiplied by the steam rate of the main turbine per water-horsepower, although in stating the duty of the main unit, it would seem more reasonable to make the comparison on the basis of shaft-horsepower, since the auxiliaries might have been arranged to be driven by the main turbine, while the method specified penalizes the main turbine for the inefficiency of the pump and that of the motor. However, taking the conditions stated, 16.26 electrical horsepower, at 16.59 lb. of steam per water-horsepower-hour, amounts to 270 lb. per hr., so that the total steam consumption of the unit would be 17,776 lb. per hr., giving a duty, including auxiliaries of 117,700,000 ft.-lb. per 1000 lb. of steam. The quality of the steam, however, was only 0.977, so that the duty based on dry steam would be 122,300,000 ft.-lb. and the steam per water-horsepower, 16.2, making the additional consumption on acount of the circulating and hotwell pump motors, 263 lb. per hr., or a corrected duty of 120,500,000 ft.-lb. with dry steam, including all auxiliaries.

Due to the small size of the intake and to low water, a certain amount of air entered the suction pipe, probably reducing the capacity and also the duty, for while a test conducted at the builder's works and later readings at Ross pumping station taken under normal water conditions showed a delivery of 108,000,000 gal. when running at 315 r.p.m., the official test showed only 102,000,000 gal. at the same speed. That the excessive suction lift and the presence of air were detrimental was also evident by shocks in the suction line, which were not experienced when the pump was running with the normal suction lift.

The pump is of the double-suction type, with 18-in. inlet and outlet openings. The casing is split horizontally and both suction and discharge openings are in the bottom part, the suction opening connecting directly to a vertical suction pipe coming up between the bearing pedestals, which are independent of the pump casing proper. The casing cover can therefore be removed without disturbing the suction and discharge connections, giving immediate access to the impeller and to all other internal parts which may be lifted out after removing the bearings caps. The impeller is of bronze, and is mounted upon a steel shaft, protected by bronze sleeves which abut against the impeller. These serve to prevent corrosion by the water and to receive any wear due to the packings.

A centrifugal pump is most likely to wear at the points where the impeller runs close to the casing, separating the suction from the discharge chamber. The pressure forcing water back from the discharge to the suction at this point is the full head developed by the pump. Originally, centrifugal pumps were provided with smooth cylindrical or flat surfaces at this point, resulting in considerable leakage initially and greater leakage later on as the clearance increased by cutting by water or wear from particles of grit and other foreign matter. To repair this damage quickly and inexpensively remov

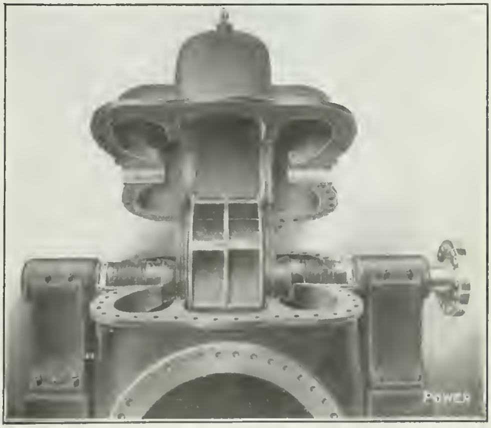


Fig. 3. Showing the Impeller

ole rings, Fig. 4, were attached to the casing and to the impeller. In the present pump, these rings are of a special type, having tongues and grooves which interlock with one another to form a labyrinth. One pair of rings is securely attached to the impeller while the other fits in recesses in the casing and may be lifted out with the impeller.

The complete pump measures 11 ft. lengthwise of the shaft and 10 ft. high. It is supported on a bedplate which is independent of the turbine and gear bedplate.

The space occupied by the turbine complete is 12½ ft. in length and 9½ ft. in height. The turbine shaft, running at 3600 r.p.m., is connected by a flexible coupling to the pinion of the double helical reducing gear, which in turn drives the pump at a speed of 350 r.p.m. The teeth are of the involute type, and are inclined at an angle of 45 deg. to the line of contact, so that 20 teeth are in contact in each pinion at one time.

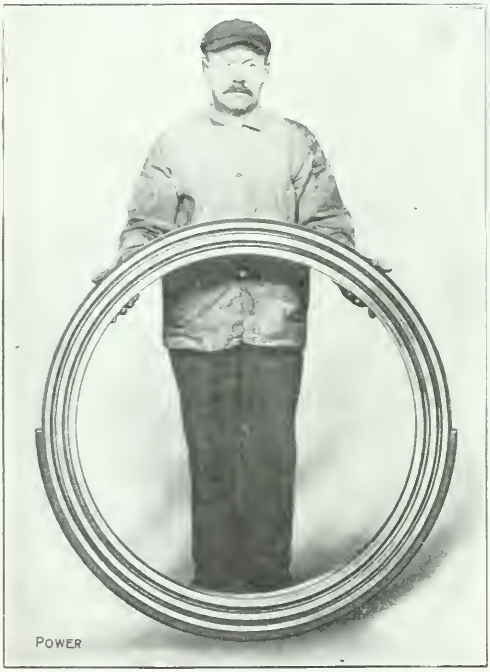


Fig. 4. Stationary Labyrinth Wearing Rings

The bearings of both pinion and gear rest in seats scraped to dimensions in a rigid cast-iron gear casing, by which they are held permanently at the center distance for which they were designed.

The condenser equipment differs from the usual in that instead of a so-called "water works" condenser in the suction line, one of standard type served by an independent circulating pump is employed. To have placed the condenser in a suction line passing water at the rate of 100,000,000 gal. per day would have given rise to excessive friction, more than equivalent to the power required to drive the independent circulating pump. The Wheeler condenser contains 2360 sq.ft. of tube surface and is placed transversely to the axis of the pumping unit, immediately underneath the turbine, so that the condenser shell connects directly to the turbine exhaust outlet by an expansion piece with free exhaust outlet connection. The circulating pump is a De Laval horizontal single-stage centrifugal pump, driven by a variable-speed motor, and is designed to deliver 3000 gal. per min. against 12-ft. head when running at 710 r.p.m. The hotwell pump is a De Laval single-stage centrifugal pump with vertical shaft, motor-driven at 1800 r.p.m. The air pump is of the rotative dry-vacuum type, with a 5-in. steam cylinder, 12-in. air cylinder and 12-in. stroke.

[It may be of interest to note that the following cities have decided to install similar pumping units, though not so large, the capacities ranging from 6½ million to 30 million gallons: Philadelphia, Toronto, San Antonio, Cleveland, Omaha and Lynn, Mass.—Editor.]

*

Standard Pipe Threads

The threads, as produced in the Briggs system, are shown in the illustration. The taper employed has an inclination of 1 in. to 32 to the axis, therefore the total taper is 1 in. to 16 in., i.e., ¾ in. to the foot or $\frac{1}{16}$ in. to 1 in. The angle of the thread is 60 deg. and its depth four-fifths of the pitch, or $0.8\frac{1}{n}$, where n equals the number of threads per inch.

Threads F are perfect at top and bottom. Back of these are two threads with perfect bottoms but flat tops; behind these are the imperfect ones produced by the chamfer of the die.

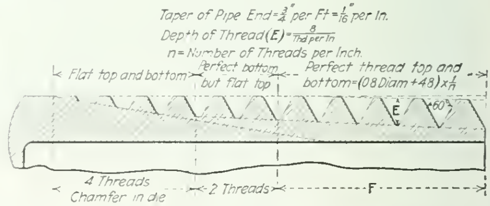
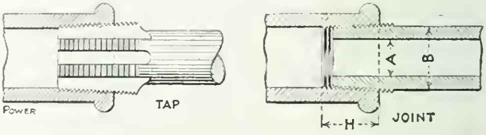

Taper of Pipe End = ¾" per Ft = $\frac{1}{16}$" per In.
Depth of Thread (E) = $\frac{8}{\text{Thd per In}}$
n = Number of Threads per Inch.
Flat top and bottom
Perfect bottom but flat top
Perfect thread top and bottom = (0.8 Diam + 4.8) x $\frac{1}{n}$
E
60°
4 Threads Chamfer in die
2 Threads
F

FIG. 1. LONGITUDINAL SECTION OF BRIGGS PIPE THREAD



Briggs' Standard Pipe Thread

It can be readily seen by the foregoing how necessary it is to have the pipe and fitting sizes match, so that the full, perfect threads in each will register with the other. A thread made up more or less than this will result in a less perfect joint.

PIPE THREADS

Diameter	Threads per Inch	Diameter of Drill
⅛	27	21/64
¼	18	29/64
⅜	18	19/32
½	14	23/32
¾	14	15/16
1	11½	1 3/16
1¼	11½	1 15/32
1½	11½	1 23/32
2	11½	2 3/16
2½	8	2 11/16
3 to 10 inc.	8	

Editorials

Work with the Firemen

On page 642 of this issue appears a short article telling of a large saving made in a boiler room through the efforts of an efficiency engineer.

Results were obtained by the simple employment of common sense and by diplomatic instruction of the firemen in better firing methods. Nothing of a radical nature was done, and the same results could have been brought about by any engineer thoroughly alive to his work. Leaks in the setting were stopped, the draft was reduced to a proper intensity, the thickness of the fuel bed was lessened, coal was fired at shorter intervals and the number of boilers on the line was reduced. The firemen were shown how to read a draft gage and were told the proper intensity for the particular fuel burned and the thickness of fuel bed carried. The use of the Orsat and the relation of its readings to economical combustion were not only explained but the firemen were shown directly the results of their work. It soon became clear to them that a complete understanding of the laws of physics and chemistry was not necessary to obtain results. It was not a difficult matter to learn how to read a gage, and by watching the results of their work under the tutelage of a competent instructor, good firing methods were gradually approached and a knowledge gained of how to maintain them.

It seems to be the opinion of many that the average fireman is not susceptible to changing hard-and-fast methods of firing; that he has been doing this work in a certain way and no doubt thinks the results he is getting are the best obtainable. It is not an easy matter to swing any man from his rut; his ways of doing things become fixed and the longer they continue, the more difficult is the change.

Of course, results in the boiler room speak for themselves, but accurate records are necessary with which to draw a comparison. Close account must be kept of the water, coal, labor employed and the output, and, above all, the fireman must be shown how to produce good results. It is not enough to hand him a log of the plant all worked out for his special benefit. To gain his confidence it is necessary to work with him in the boiler room. Tell him the reason for every change made and by means of the draft gage and the Orsat, show him the direct results. Any man with a spark of intelligence will respond to such treatment. His interest will be aroused and when he starts to ask questions, the hardest work is finished.

Then is the time to bring out the log. Let him know the results he is getting from day to day and from month to month. Give him access to good power-plant books and periodicals, so that in his reading he may draw a comparison between other plants and his own. Give him a clean place in which to work, wash and dress, and pay him a suitable wage for handling the largest item in power costs. In other words, make the fireman a real cog in the wheel of power-plant operation, and see that each element is well greased to preserve uniformity and smoothness of operation.

A saving of thirty-five per cent. in the coal bill is not small. There would not be the same opportunity in all plants, but in the great majority some saving could be made. A little pioneer work with the firemen at the source of steam power will prove worth while. Try it out in your own plant and let us know the results.

*

Buying Power Machinery

Many buyers of power and other machinery do not know how to buy. They do not seem to know exactly what they want, which is often natural and permissible, but they should know what is to be expected of the new machinery, and that is what the manufacturer always wants to know.

For instance, an owner finds that he is burning too much coal. He wants to invest in apparatus that will net him returns. So, he writes to a manufacturer who claims to have the cure-all. He doesn't send any plant details, just a letter saying: "How much would it cost to install your apparatus? We have return-tubular boilers and a noncondensing Corliss engine. We now use ——— pounds of coal per year. How much would you apparatus save?"

The manufacturer replies with a general letter, stating what his apparatus has done for others, names his price, asks for pipe-connection details, sends a catalog or so, and rests his case.

The buyer sends the pipe details and asks for more information. He receives an immediate reply, consisting principally of sales arguments.

After an exchange of a few more letters, in which the manufacturer usually shows the upper hand because of his better knowledge of efficiency apparatus, the buyer succumbs and buys, and there the deal ends. Sometimes the sale is made even more quickly than this.

The manufacturer is not dishonest. The apparatus he sells doubtless improves economy, and the buyer may be perfectly satisfied, but that does not say he made the best investment. It is better than none at all, but he did not make the most of his opportunities, because he did not know how to go about it. His knowledge of modern machinery is hazy. He does not know what is best, so makes a blind stab at efficiency in general, using what he thinks is his best judgment.

The proper way to buy power and other machinery is to first write out all power-plant conditions in detail that would or might be affected by the new apparatus. The more the manufacturer knows about the plant the more accurate will be his figures and recommendations. A sketch or sketches should be made, preferably to scale, showing the present arrangement and giving the principal dimensions. Then, what the new machinery is to accomplish should be explained.

With this done it will be unnecessary for the manufacturer to write letter after letter. He will appreciate that "sales arguments" will not help him much, that he is dealing with a man who knows what he wants and who wants "figures" and not arguments.

Let this matter be sent to the manufacturer with a stamped envelope for its return, so that it can be sent to competing firms, or better, let several copies be made of the sketches and instructions, so each manufacturer may keep a set, and all be working on the proposition at once.

It should be insisted that the new machinery must do the maximum work, year in year out, for each dollar invested, and the maker should be asked to use plain, understandable words in his recommendations and guarantees. Nothing should be accepted that is not understood, and no hesitation should be felt to inquire into the why and wherefore of every little detail. This will prevent future sorrow.

Neither should there be any backwardness about requiring guarantees under bond. That the manufacturer is reliable and well established should be determined at the outset. New firms will be glad to be investigated thoroughly.

In this way the purchaser does not specify the machinery himself. The manufacturer does the specifying. Virtually the problem is put "up to him," which is logical, because all wide-awake manufacturers are well versed in all modern power-plant apparatus and will do as much for their customers as possible. It is not uncommon for firms to "turn down" orders and recommend competing apparatus. They would rather do this than have their own fail to perform better work than their competitor's. Being given conditions in detail, each manufacturer can tell quite accurately whether or not his machinery will be best and the purchaser will reap the benefit.

Small Leaks and Big Ones

In this week's leading article are the details of a remarkable saving made in a hotel power plant. The reduction in operating expense was enormous for a plant of its size. The machinery was new and should have operated at its highest efficiency, but it was the same old story of "the man behind the gun." The hidden losses were allowed to sap the vitality of the plant, little attention was given to operating schedules of the large machines and the auxiliaries, and apparently there was no effort to secure reasonable economy in the boiler room. Live steam was allowed to blow to the four winds. True it did it behind iron walls, but an investigation would have readily shown up this loss. The machinery was not kept in the best condition and it is clear that little effort was made to secure economical results.

All this was changed when a real engineer came on the job. Strict attention to duty was the rule. The hidden losses were detected and stopped, and at every possible point a saving was made. The boiler furnaces were remodeled and produced results sixty per cent. better. Operating schedules were carefully planned. Complete records were kept and interpreted by an engineer thoroughly familiar with his work. It is not surprising that a saving was made, but the size of it emphasizes the importance of stopping the small leaks and avoiding the big ones. The latter are usually visible, but the former require constant vigilance and attention to duty at all times. It is these small losses which in the aggregate determine the status of a plant and their detection the caliber of the engineer.

Ash Content of Coal

The relation between the ash content and the value of coal used as a fuel is a matter of special interest to power-plant engineers. Unfortunately, but little has been published in the technical press regarding the findings of those who have investigated the subject to determine the real value of the fuel supplied to the boiler furnaces.

Naturally, the freight charges have much to do with the final value of coal as a fuel, and there is no economy in purchasing coal containing 30 or 40 per cent. ash, upon which a high rate of freightage is charged and from which no heat value is obtained in return for the expenditure; there is also the cost of ash removal. Where power plants are close to the coal fields, coal with a high ash content would be worth considering.

In Power of Sept. 22 there was published an article dealing with the question of ash, and on page 649 of this issue is another. It is interesting to compare the two findings as one article deals with anthracite and the other with bituminous coals.

Mr. Ellis found that the best results could not be obtained from coals having an ash content greater than fifteen per cent. He allowed one and one-half per cent. depreciation in the coal value for each one per cent. of ash content, and rejected as worthless any coal above fifteen per cent.

An article in the April 25, 1911, issue by A. Bement, analyzing the coal problem, gives valuable data concerning the ash content in coal.

Rate Decision

We understand that the New York Public Service Commission is about to render a decision relative to the rates of the New York Edison Co. This is the outcome of several complaints which have been pending for the past two years. The apparently slow progress has frequently been the subject of severe criticism, but, considered from all angles, Commissioner Maltbie is to be commended for proceeding cautiously in his endeavor to ascertain all the conditions and thus arrive at sound conclusions.

One noticeable feature of the hearings has been the apparent change in attitude of the officials of the Edison company, who, at first were almost dogmatic, but as the hearings proceeded gradually receded from this stand and began to show a greater willingness to coöperate with the Commission, especially in furnishing information.

With the complexity of service conditions in a city such as New York, the establishment of equitable rates is no easy task, but it is hoped that the decision will be such as to settle the question, and not make recourse to the courts necessary.

* * *

Even such a cold and chilled profession as that of the refrigerating engineer is affected by the war. The secretary of the International Association of Refrigeration announces that the publication of the *Bulletin* has been suspended, owing chiefly to lack of coöperation by those from the countries now engaged in hostilities.

Correspondence

Trouble with an Air Lift

In testing the capacity of each well separately, I found that they were not delivering the right amount of water. Like Mr. Lacy (page 504, Oct. 6), I lifted the air lines and found the same kind of a foot piece. I changed it, and increased the size of the air pipe to $1\frac{1}{4}$ in. from the air receiver to 150 ft. down the well. Then I put on a bullhead tee, $1\frac{1}{4}\text{x}\frac{3}{4}\text{x}\frac{3}{4}$ in., with two $\frac{3}{4}$-in. street ells, having $\frac{3}{4}\text{x}\frac{1}{4}$-in. bushings and $\frac{1}{4}$-in. nipples 3 in. long, screwed into the street ells, making sure to turn the ells looking up. If Mr. Lacy will do the same I am sure he will have no further trouble.

MICHAEL A. QUICKER.

Belmar, N. J.

⁂

Steam-Gage Connections

On p. 427, Sept. 22, C. E. Anderson describes a change in the steam-gage piping. How would opening the blowoff cock remove the sediment in that gage pipe? It would drop down past the blowoff connection, settle in the bottom of the pipe, and could not be cleared without removing the gage and blowing through.

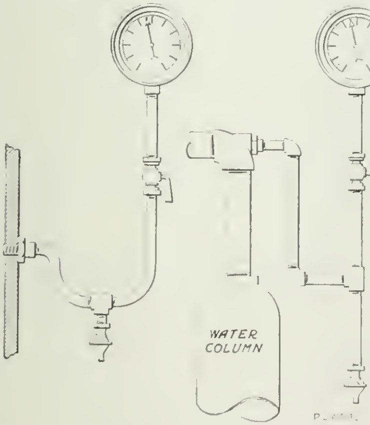


FIG. 1 FIG. 2

CUSTOMARY CONNECTIONS

The coil is of no use, as the trap in the pipe would protect the gage. A gage connection, as shown in Fig. 1, is considered good practice, and Fig. 2 is recommended by the Hartford Steam Boiler Inspection & Insurance Co.

FORREST R. CARPENTER.

Salmon Falls, N. H.

Without doubt, the drain-out cock was placed at the lowest point to drain out all particles of dirt or scale. The old connection is advised by boiler makers, insurance companies and inspectors as the best for all practical purposes.

If Mr. Anderson's new connection should happen to fill at the lowest point—and I cannot see what will prevent it—he will have to take off the steam gage to blow it out and, worse, he could not tell if it was filled until his gage did not work right.

The remedy is much the same as if his fireman should happen to leave the boiler blowoff open long enough to burn the plates or tvbes and he should move the blowoff connection up a few feet.

BARCH SMITH.

Newark, Ohio.

⁂

Influence of Ash Content of Coal

In an address before the meeting of the National Electric Light Association in Philadelphia last June, Elbert Hubbard in substance said: "Darn the man that plagiarizes your thoughts before you have an opportunity to express them yourself." This is brought to mind by the article in the Sept. 22 issue on the "Influence of Ash Content of Coal," and the fact that I have purposed publishing the results of some investigations we have been making on ash content in coal.

As the article dealt with anthracite coal and our investigations considered bituminous coals exclusively, it may prove of interest to compare the results of the two findings. We undertook to ascertain the exact relationship between the ash content and the value of the coal under our conditions of operation. The relationship discovered is believed to hold closely in the average plant.

Most contracts for coal purchased upon the basis of its heating value are predicated upon the hypothesis that the value of the coal closely approximates the value indicated by the calorimeter. Practically all of such contracts seem to recognize that the ash content influences this value and they penalize an excess of ash. No contract under the writer's attention has attempted to penalize the ash content on any other than an empirical basis, and the article referred to is the first seen that has attempted the solution of the problem.

Our starting point was the proven fact, as stated in a bulletin of the coal-testing plant of the Government, that a coal with an ash content as high as 40 per cent. was worthless as it was difficult, if not impossible, to keep it ignited, in an ordinary furnace. We have had no such coals, but have had them approximating 30 per cent., and the results lead us to assume the correctness of the Government report.

Coal apparently follows a straight line characteristic, as regards its value in the calorimeter on a basis of its ash content, assuming the same character of coal, and a nearly straight line though at a different angle, as regards its usable value in the furnace. This last curve drops a little as the ash content nears 30 per cent., beginning to drop at about 20 per cent., and presumably this increases in curvature toward the point of zero value. These results seem similar to those for anthracite coal in the previously mentioned article.

Since the personal equation of the fireman greatly affects the results obtained from the same coal on two successive days or different parts of the same day, it is difficult to keep all of the factors the same in a combustion test and the results are approximate at best.

It is also remarkable to note the closeness of the formula we have been using to evaluate our coal to the results obtained by Mr. Philo. Because the curve begins to drop rather rapidly between 20 and 30 per cent. ash and in practice we use coals having an ash content of 15 per cent. or less, we have settled upon 1½ per cent. depreciation in the coal value for each 1 per cent. of ash content; we reject as worthless for our uses any coal above 15 per cent. Were we closer to the coal fields, with consequent lower rate on coal freight, it would probably pay us to consider coals with higher ash content, but under our conditions we cannot afford to pay freight on the ash.

In practice, then, in estimating the probable value of coal, we use the formula:

$$\textit{value of coal} = \frac{C + F + U}{\textit{B.t.u.} \quad (\textit{B.t.u.} \times 1\tfrac{1}{2} \textit{ ash per cent.})}$$

where

C = Cost of coal at mine per ton;
F = Freight rate per ton;
U Unloading cost per ton;
$B.t.u.$ = Heat value by calorimeter per ton.

Considering the fireman and the inability to keep our conditions exactly constant, this formula gives us results as nearly correct as we can determine. In other words, the errors caused by its use are well within the errors of observation and measuring instruments.

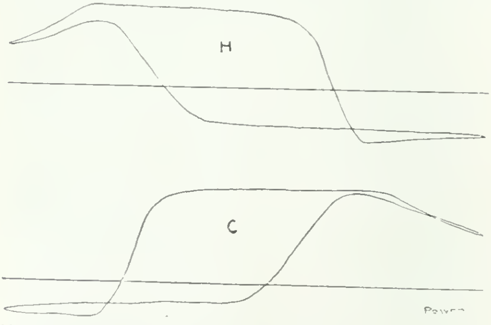
R. L. Ellis.

Selma, Ala.

⁂

Indicator Diagrams for Comment

The accompanying diagrams were taken with a 50-lb. spring from the high-pressure cylinder of an 18 and 32 by 24-in. condensing engine running at 60 r.p.m. The engineer in charge says the engine is doing very good work, and gives no trouble except for a very heavy pound when the rod passes the centers. Can anyone tell what the trouble is as indicated by the diagrams?



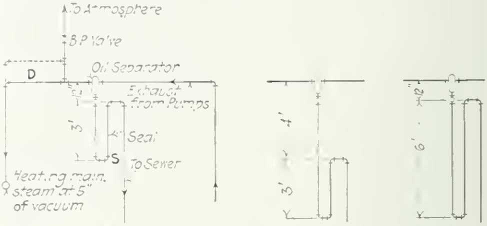
Head and Crank-End Diagrams from Steam Engine

Thomas McNamm.

Newark, N. J.

Oil Separator Failed to Work

An oil separator connected as shown in Fig. 1, did not remove the oil from the exhaust of a number of steam pumps in a case where 5 in. of vacuum, or 2.46 lb. below atmospheric pressure, was maintained on the exhaust steam main at the point where the separator was connected. Upon close examination the reason became apparent. The height from the bottom of the seal to the exhaust main was only 4 ft., so that only 4 ft. × 0.434 lb. = 1.736 lb. below atmosphere would lift this seal to a height where the oil could be swept into the heating system.



Seal for Oil Separator

Figs. 2 and 3 show how such a condition may be obviated, either of which arrangements will require a pressure of 6 ft. × 0.434 lb. = 2.6 lb. below atmosphere, to lift the oil in the steam to a height of one foot below the exhaust main. Further change should also be made in this piping for better oil separation as indicated by the dotted line at *D*, Fig. 1.

If the pressures were reversed in direction—i.e., if a back pressure of 2.46 lb. above atmosphere was carried on the exhaust main—then only 3 ft. × 0.434 = 1.3 lb. gage pressure would be required to blow out a seal such as shown in Figs. 1 and 2.

T. W. Reynolds.

Mt. Vernon, N. Y.

⁂

An Interesting Cylinder Failure

Under the above heading in Power of July 14, there is a description of an accident to an engine. The conditions at the time are stated and the deduction is made that water was pumped back from the receiver into the steam chest, which then cracked from over-pressure.

With the engine running forward and the valve-gear in a forward position, I do not see how water could be so pumped. Assuming that the piston is traveling toward the head end, and that the head-end exhaust valve is open and the steam valve closed, any water which might be in the cylinder would have a chance to escape through the exhaust valve until compression begins. If more than sufficient water is entrapped than will fill the compression space before the steam valve opens, then the cylinder head will likely be driven out, the connecting-rod bent, the crankpin broken, or the main bearing split. After the steam valve opens, the water can pass to the steam chest. But there will be mighty little of it, because the piston is about at the end of its travel when the valve opens. This process would be repeated at the crank end; therefore I do not see how sufficient water could be accumulated in the steam chest by the pumping process to damage it. The tendency would be to reduce the amount of water there.

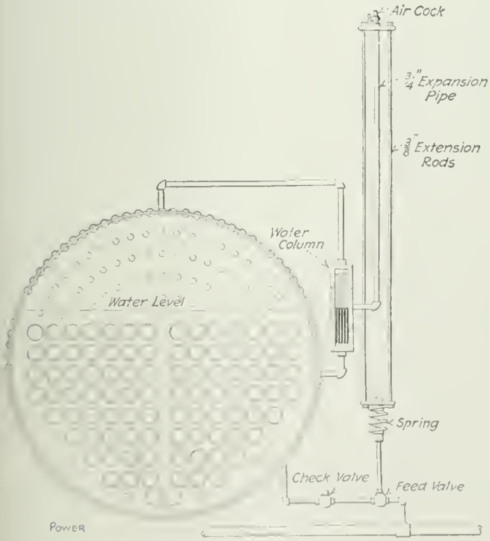
It looks more probable that the engine was stopped in such a position that both valves were closed and that the throttle leaked. Then when the chest was full of condensation, water-hammer cracked the chest. Of course, there would be noise from water-hammer and leakage from the engine, but what of that? The fact that the separator drain was plugged and the trap discharge valve closed shows that the motto of the plant was "In God we trust." If the engine were running backward with the gear in the forward position or if it were running forward with the gear in the backward position, we would have an almost ideal pump, but we have no evidence that such was the case.

R. McLaren.

Medicine Hat, Can.

Home-Made Feed-Water Regulator

An engineer called my attention to his home-made feed-water regulators. He had made them out of odds and ends of pipes and rods about the plant and claims to have the simplest regulator in the world. I do not doubt his statement.



Regulator Connected

He says they have never fooled him yet and he has perfect confidence in them. The illustration is self-explanatory.

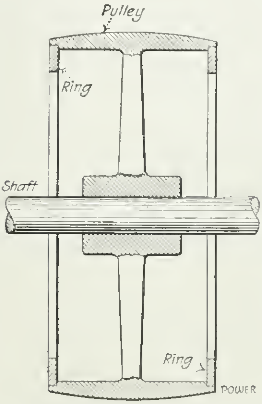
The process is one of balance, the feed valve is maintained in a certain position, feeding gradually and continuously maintaining an almost even level of water in the boiler. When the water lowers below the second gage cock, steam enters the "expansion pipe" and raises the rod, opening the feed valve. When the water in the column gets above this gage, water enters the "expansion pipe" and contracts it, pushing the rod down, thus closing the valve shutting off the water.

Luke Matier.

Fall River, Mass.

A Water-Cooled Pulley

Preparing to make a brake test on a small motor not long ago, I did not know where to get a water-cooled pulley in a hurry, so I made one out of a standard cast-iron pulley and a couple of welded wrought-iron rings. I first bored out the inner edges of the pulley rim, then turned the outside of the rings to make a driving fit, being careful, of course, not to make the fit so tight as to break the cast-iron pulley.



Flanges Fitted to Pulley

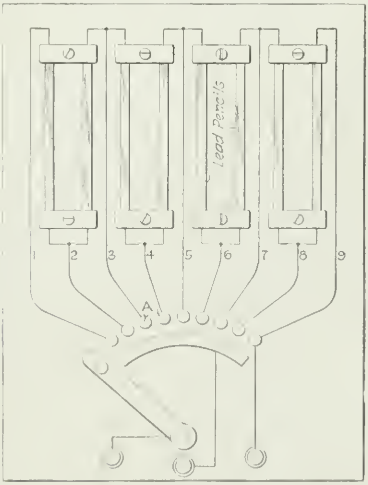
So far as I know, the pulley never gave any trouble. It leaked water a trifle at first, but rust quickly mended the leak.

S. F. Wilson.

New York City.

Lead Pencil Starting Rheostat

Once I had to temporarily install a two-horsepower motor and needed a rheostat for starting it, but did not have the necessary wire to make one. Therefore, I built up one, using ordinary carpenter's pencils for the resistance, as shown in the sketch. The results were very satisfactory.



Homemade Rheostat with Lead Pencils as Resistance

It consisted of a wooden board covered on one side by a sheet of asbestos on one face upon which rested the part that composes the rheostat. Standard porcelain cleats were used to hold the pencils and the end connections were made by wrapping a thin sheet of copper around the ends of the pencils. This copper, in turn, was soldered to No. 14 copper wire, the free ends of adjacent sections being joined. In order to avoid breakage of the lead by the pressure of the cleats, the ends were protected by asbestos cord.

The contacts, *A*, were fixed on the lower part of the board forming an arc of a circle and the ends of the wires 1 to 9 were attached to the respective contacts.

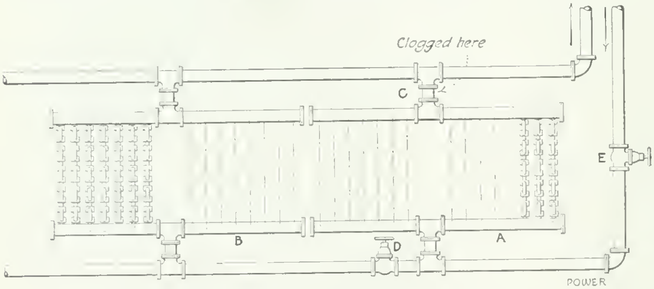
F. P. Ampudia.

New York City.

Condenser Trouble

The construction of one of our ammonia condensers is shown in the illustration. It is of the double-pipe design, having twelve pipes to the stand and two sections of 15 stands each.

When starting up this season, section *A* ran much warmer than section *B*, and the temperature would be practically uniform at top and bottom, when there should be about 20 to 30 deg. difference. In warm weather, the branch header and three or four pipes up from the bottom on section *B* would be sweating while the branch header on section *A* would be perfectly dry.



Arrangement of Piping and Point of Stoppage

We decided that section *B* was getting more than its share of the circulation, and put in a valve at *D* to throttle the supply to section *B*.

This proved unsatisfactory, because any attempt to throttle the supply to this section resulted in running up the ammonia head pressure and increasing the temperature of section *A*.

Finally, I put a gage at the top of one of the coils near the header and shut off valve *D*. The pressure instantly went up from 10 to 60 lb., the pressure carried at the pump. Evidently, the branch header at the top of section *A* was obstructed. When the caps on the ends of the branch header on section *A* were taken off and a rod run through it, a few particles resembling limestone were brought out. By hammering the branch outlet *C* several lumps came out, each large enough to practically obstruct the pipe.

The trouble was originally caused by a bad pipe allowing the ammonia to leak through into the water. The water used is from two artesian wells carrying a large amount of scale-forming matter which is deposited by the heat at the top of the condenser. When the ammonia combined with the scale, it formed the chalklike substance in the pipe. The defective coil was located close to the obstructed outlet and the deposit accumulated here until it filled the pipe. During the winter, while the condenser was shut down, it hardened to a solid mass and totally obstructed the outlet.

Thomas G. Thurston.

Chicago, Ill.

Engine- and Boiler-Room Signal System

It sometimes happens that there is lack of coöperation between the engine-room and boiler-room operators, caused by the failure of the former to give prompt notice to the latter in the event of a change in the demand for steam. It finds expression in the shifting of responsibility from one side of the wall to the other for the resulting low steam or bare grate surface. The engineer blames the water tender or man in charge of the boiler room for the drop in pressure, and the water tender blames the engineer for bare grates because he cannot tell when he may be called on for more steam. Aside from the unpleasantness arising from such conditions, it lowers the plant efficiency and affects the coal pile.

To secure the best results, the man in the boiler room must know at all times what is going on in the engine room and be able to anticipate changes in load. The following signal system has been successfully used as a synchronizer for these two departments by a large plant in the Middle West:

There are nine 900-kw. units in the engine room, each represented by an incandescent bulb in the boiler room and so connected that when the switch is thrown at the board, cutting a generator in on the line, a circuit is closed with the light in the boiler room and the lamp remains bright till the switch is pulled and the generator taken off the board. The lamps are inclosed in a long box having frosted glass sides and nine compartments, each numbered to correspond with the unit which the light within represents, so that at any time the boiler-room operator may tell at a glance the number of engines steaming and instruct his firemen accordingly.

In addition to this, there is a gong system which serves as a warning to the water tender or man in charge of the boiler room when there is to be a change in load due to the shutting down or starting up of one or more engines. One ring means that less steam will be required after the change, and two rings that more will be necessary. The warning is given, if possible, at least half an hour before the change in load occurs.

Such a system is fairly complete, and enables the boiler-room operator to keep in touch with things in the engine room and run the boilers more efficiently. When the value of such systems is realized, one wonders why they are not more generally used.

A. W. Conklin.

Wyandotte, Mich.

Preheating Furnace Air

Mr. Olmstead's letter on page 24, July 7, (see also Aug. 4, page 179, and Aug. 11, page 217) recalls a time I wanted to try a system somewhat similar, employing waste exhaust steam. After comparing the cost and the benefits I gave it up.

In marine practice the Howden system, in which the furnace air is heated by tubes in the uptake, is quite old. Due to the high temperature of the flue gas the air is raised to 300 deg. or over, and combustion is very rapid, but the grates burn out in a short time. High furnace temperatures cause clinker, while the same coal if burned in an ordinary furnace is satisfactory.

Many Howden preheaters operate economically, though it is necessary to keep the air temperature lower than Howden first planned.

A scheme devised for torpedo boats consisted of a water-tube boiler similar to the Thornycroft. On the outside an iron casing conducted the air to the grates, the object being to recover most of the heat usually lost by radiation, and incidentally to cool the fireroom.

That any system employing waste heat is economical is not to be questioned, but it is doubtful if the cost of installation, maintenance and depreciation is justified unless, perhaps, in sections where coal is expensive, and even then the economizer seems preferable.

WILLIAM E. CALDWELL.

New York City.

In the system of preheating air described on page 179, Aug. 4, a fan is so arranged that the air used for combustion is drawn from over the boilers. It is claimed that much coal is being saved, but I believe that except for ventilating the boiler room, such a system is useless, if not wasteful.

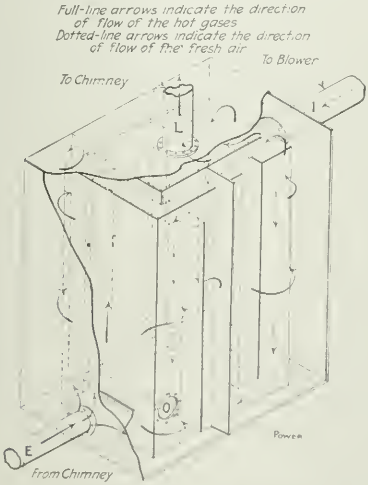

Full-line arrows indicate the direction of flow of the hot gases
Dotted-line arrows indicate the direction of flow of the fresh air
To Chimney
To Blower
L
I
O
E
From Chimney
Power

FIG. 1. CONSTRUCTION DETAILS OF HEATER

The heat in the boiler is derived from the coal, and unless the surface of the boiler is covered with some nonconductor, a great deal of the heat in the steam will be lost by radiation—and imagine how much more when comparatively cold air is continuously passing over the boiler. Of course, some heat is returned to the furnace, but there is a loss just the same.

A system for preheating air by utilizing the heat that otherwise escapes through the stack is here suggested: Fig. 2 shows the heater *H* in connection with an ordinary tubular boiler. The fan blower *B* is connected to the heater by the pipe *I*, and *O* is the pipe leading from the heater to the ashpit. Pipe *E* connects the heater with the breeching, the point of connection on the latter being a little below the damper, and the hot gas, after passing through the heater, returns to the breeching through the pipe *L* above the damper.

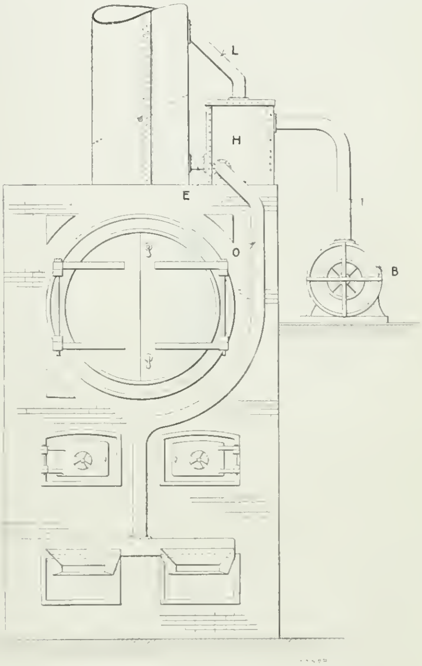


FIG. 2. GENERAL OUTLINE OF AIR PREHEATER

Fig. 1 shows the internal arrangement. The air from the blower, entering at *I*, passes through and escapes through *O*. The hot gas from the breeching enters at *E*; impinges against the baffle-plates, then takes the course shown by the full-line darts in such a way that every part of the surface is heated by the gas coming directly in contact with it.

A wire screen secured to the breeching end of the pipe *E* will keep out the cinders that would otherwise settle inside of the heater. The air line *I*, being comparatively large, reduces the air velocity as it enters the heater, thereby permitting it to remain in the heater long enough to absorb a large amount of heat.

As the gases in the breeching usually have a temperature of 350 to 650 deg. F., it is easily seen that the air for combustion will be given a very high temperature, not at the expense of the heat that should be put into the steam but by reducing the stack temperature.

The heater is simple and may be constructed of $\frac{1}{8}$ in.

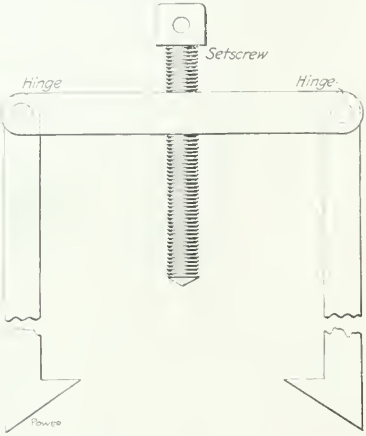
galvanized iron and $\frac{1}{16}$-in. iron would be heavy enough for pipes *I* and *O* to give lasting service. One or two handhole plates at suitable points would be useful.

Samuel L. Robinson.

Providence, R. I.

Clamp for Safety Valve

A clamp for a safety valve to prevent it opening when applying a hydrostatic test to a boiler is shown in the illustration. The clamp is placed over the valve, the arms hooked under the valve body and the setscrew set down on the spindle preventing the disk from lifting. This saves the trouble of increasing the tension on the spring and resetting to the right pressure after the test.



Adjustable Valve Clamp

W. Wrightson.

Jamaica, L. I., N. Y.

Uniform Boiler Legislation

The publicity given the enactment of uniform license and boiler laws through agitation by engineering societies should arouse sufficient interest among public officials to cause the passage of sound uniform rules and regulations governing the construction and operation of steam boilers.

Every now and then we hear of an explosion caused by some negligent employee or employer allowing a boiler to be operated in an unsafe condition, either unknowingly or hoping that the boiler would pull through the season without having to spend money to put it in good shape.

Such a condition came to my attention when we were called to make a report on a plant from which severe complaints regarding the fuel had been received. An investigation showed that the boiler tubes were very dirty, the combustion chamber full of ash, even touching the boiler shell, the bridge-wall covered with clinker and with but little space between it and the shell; the air spaces in the grate were plugged with clinker and melted glass, the safety valve, of the lever type, was stuck fast and the blowoff connections looked as though they would fall apart.

The engineer has been there months and had not "discovered" that the grates were of the shaking type; neither had he initiative enough to open the boiler to examine the interior. These conditions existed in a woman's home, a semi-charitable institution where a large number of people were housed, and all subject to the results obtained by an incompetent boiler operator.

In such cases, enactment of laws would be of little benefit; enforcement is what we really need.

J. B. Harris.

Minneapolis, Minn.

Allowance for Expansion

Like E. R. Pearce, on page 465, Sept. 29, I have seen a bronze bearing heat sufficiently to slow down a 125-hp. engine and freeze to the shaft almost instantly.

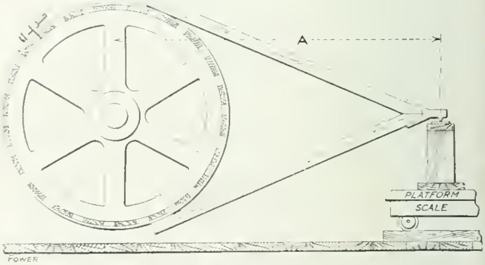
It was on a 40-kw. generator and it was a strict rule to make sure that the oil rings had begun to revolve immediately after starting the engine. This was done as usual when the engine was started at 12:50, and before the load came on at 12:55, the engine suddenly slowed down to less than half speed, accompanied by the screeching of belts. The engineer threw out the clutch driving the generator. Upon examining the bearing it was found that but little damage had been done to it or the shaft, although it was necessary to use a jack to get the bearing off the shaft. The oil well was full of clean oil and no defect could be found in the ring, which was revolving properly less than five minutes before. This bearing, to my knowledge, ran perfectly before this and for two years afterward. The strangest feature was that the bearing seized the shaft so firmly without seriously damaging itself or the shaft, the generator being shut down only four hours as a result.

I. S. Chamberlain.

Jersey City, N. J.

Prony Brake

When making a prony brake it will simplify the calculation if the arm is of such length that the distance *A*, in the illustration, is 63.024 in., or the radius of a circle the circumference of which is 33 ft. If *W* equals the weight on the scale and *N* the revolutions.



Length of Arm Affects Formula

$$hp. = \frac{2\pi AWN}{33{,}000}$$

will be simplified to

$$hp. = \frac{WN}{1000}$$

M. E. Griffin.

Franklin, Penn.

Engineers' Study Course

Problems in Power-Plant Design--III

Power for Lighting

In a previous article, the capacity and size of the main generating set for supplying the entire plant with power was determined. The next step is to make similar computations for the lighting plant. As already stated, the details of this part of the work will not be included in the problem, our attention being confined to supplying power for the same. If the lighting requirements are given in watts, the capacity of the generator in kilowatts is found by dividing this quantity by 1000, and increasing the result a small amount, say 5 per cent., for transmission and other losses.

Sometimes a list of lamps for the entire plant is given, with the current in amperes required by each. In cases of this kind, the total number of amperes multiplied by the voltage of the system will give the watts, from which the capacity of the generator may be found as before. If no data are given, and the power must be approximated from the plans, we may proceed as follows:

First, assume the lighting requirements in each building, and decide upon the type of lamp to be used; then assume the candlepower or watts required per square foot of floor space, and work out the requirements along this line from dimensions given on the plans. All results should finally be reduced to watts, and from the total thus found the capacity of the generator can be determined as previously described. In general, erecting shop, foundry, forge shop, power house, storage space, etc., are best lighted by arc lamps, supplemented by incandescent lamps at special points if needed. In the case of the machine and pattern shops incandescent lighting is preferable on account of the absence of shadows and the ability to concentrate the light at the point most needed. Incandescent lighting is also employed for offices and drafting rooms for the same reasons, and for the softer quality of the light. For outside lighting the arc lamp is generally more satisfactory. As the power of arc lamps varies so much under different conditions, it is customary to give the requirements in watts per square foot of floor space when making approximations of this kind.

In the case of incandescent lighting, candlepower per square foot of floor space is commonly used, allowing about $3\frac{1}{2}$ watts per candlepower for lamps with carbon filament and $1\frac{1}{4}$ watts for the tungsten lamp. For average conditions, the following requirements, taken from "Power, Heating and Ventilation," may be assumed: For dwelling houses, with brilliant illumination, one candlepower may be allowed for each 2 to 3 sq.ft. of floor space and for general illumination, one candlepower for each 4 to 5 sq.ft. of floor space, strengthened by special lamps where required. In the case of offices, public halls, etc., one candlepower is required for each 3 to 4 sq.ft. of space for ordinary conditions, while for brilliant illumination, or where ceilings are very high, this should be reduced slightly.

Drafting rooms require one candlepower for each 1.5 to 2 sq.ft. of floor space to give the best results. The efficiency of 3.5 watts per candlepower is for the ordinary 16-cp. carbon light when new.

While some of the newer types of lamps have a higher efficiency, this is on the side of safety and may be used for approximate work in case the particular type of lamp is not known. In case of arc lighting, Table 1 may be used for approximating the current required.

TABLE I

Building or Room Lighted	Watts per Sq.Ft. of Floor Space
Machine shop	0.75
Foundry	0.6
Forge shop	0.6
Erecting shop	0.6
Storage space	0.4
Power house	1.0

Multiple-arc lamps would probably be used in the present case, as they can be run at the same voltage as the incandescent lamps. These are made in different sizes; the standard 110-volt lamps of the General Electric Co., take 4, 6 and 7.5 amp. each.

Taking up the different buildings and departments, we find from the plans the following floor space to be lighted:

ARC LIGHTING

Erecting space in machine shop, sq.ft	16,000
Foundry, sq.ft.	15,000
Forge shop, sq.ft.	5,000
Storage space, sq.ft.	14,000
Power house (estimated) sq.ft.	5,000
Carpenter and paint shops, sq.ft.	3,000
Ten outside lamps.	

INCANDESCENT LIGHTING

Machine shop, sq.ft.	24,000
Tool room, sq.ft.	4,200
Pattern shop, sq.ft.	4,200
Drafting room, sq.ft.	4,200
Offices, sq.ft.	4,200

Under arc light, the different departments may be classified as follows:

	Erecting space, sq.ft.	16,000
	Foundry, sq.ft.	15,000
	Forge shop, sq.ft.	5,000
(1)		36,000
(2)	Storage space, sq.ft.	14,000
(3)	Power house, sq.ft.	5,000
(4)	Carpenter and paint shops, sq.ft.	3,000

Taking the watts per square foot of floor space for the different departments from Table 1, and assuming the requirements in the carpenter and paint shops to be the same as for a machine shop, gives:

(1)	36,000 × 0.6	21,600
(2)	14,000 × 0.4	5,600
(3)	5,000 × 1.0	5,000
(4)	3,000 × 0.75	2,250
	Total watts	34,450

To this must be added the current required for the outside lighting. Assuming the lamps to be the equivalent of those requiring 6 amp. on a 110-volt circuit, we have the following requirements for this purpose:

Taking up the incandescent lighting on a candlepower

$$110 \times 6 \times 10 = 6600 \textit{ watts}$$

basis, we have

	Machine shop, sq ft	24,000
	Tool room, sq ft.	4,200
	Pattern shop, sq.ft.	4,200
(6)		32,400
(7)	Drafting room, sq.ft.	4,200
(8)	Offices, sq ft	4,200

Computing the lighting of group (6) on a basis of 4 sq.ft. of floor space to one candlepower; group (7) on 1.5 and group (8) on 2 sq.ft. per candlepower, and assuming an efficiency of 3.5 watts per candlepower gives:

$$\begin{array}{lrr}
(6) & \frac{32{,}400}{4} \times 3.5 = & 28{,}350 \\
(7) & \frac{4{,}200}{1.5} \times 3.5 = & 9{,}800 \\
(8) & \frac{4{,}200}{2} \times 3.5 = & 7{,}350 \\
\hline
 & \text{Total watts} & 45{,}500
\end{array}$$

The total for the plant would be

$$34{,}450 + 6600 + 45{,}500 = 86{,}550 \textit{ watts}$$

which, after allowing a 5 per cent. line loss, calls for a generator of practically 90-kw. capacity.

In buildings like the foundry, forge shop, etc., it has been assumed that the entire lighting will be done by arc lamps, when, as a matter of fact, a considerable number of incandescent lights will be used in each case. This, however, will not affect the result to any appreciable extent and simplifies the process of computation somewhat. The next step is to decide upon the number of units to use and the method of proportioning the power among them.

As the lighting load in a plant of this kind is light during the day, and is at a maximum for only a short time at morning and night, it is desirable to have several units so arranged that as the load increases their power may be successively added as required. The relative size of the units is a matter upon which there is some difference in opinion. While the best economy is secured where large machines are used during periods of heavy load, and those of small size during light loads, certain practical considerations may lead to a different course. It is the custom of many engineers to divide the total capacity into three units of such size that any two of them by running at 20 to 25 per cent. overload, can do the entire work satisfactorily. This permits of shutting down one unit in case of repairs, and also the three are interchangeable on the work. With this arrangement only one set of repair parts need be kept on hand, which is often a matter of some importance.

In some cases the power is divided among three units of equal size, designed to do the work at their normal capacity, and an extra unit of the same size provided for use in case of an emergency. This allows for a spare machine at all times and allows for a "rotation" in the use of the different units.

A good arrangement in the present case would be to provide three units, one of 60-kw. capacity, and two of 30 kw. each. The larger machine and one of the smaller ones would do the regular work, and leave a spare machine of the smaller size. In case of repairs to the larger unit, the two smaller ones could be used and the remainder of the load be thrown upon the main power generator which is provided with a certain amount of surplus for this purpose.

Having decided upon the sizes of the generators, the next step is to determine the indicated horsepower of the engines for driving them. This depends upon the efficiencies of the engine and generator, and is given by the formula:

$$i.hp. = \frac{kw. \times 1000}{746 \times A \times B}$$

in which

i.hp. = Indicated horsepower of engine;
kw. = Kilowatt rating of generator;
A = Efficiency of engine;
B = Efficiency of generator.

For full loads, under ordinary conditions, we may assume an efficiency of 80 to 85 per cent. for engines up to 100 i.hp., and 85 to 90 per cent. for larger sizes; and efficiencies of 85 to 90 per cent. for generators up to 100 kw., and 90 to 95 per cent. for larger machines. Taking the higher efficiencies given above, the indicated horsepower of the engine equals the kilowatt rating of the generator times 1.75 for generators up to 100 kw., and kw. × 1.57 for larger sizes. Applying these relations to the case in hand gives

$$30 \times 1.75 = 53 \textit{ i.hp.}$$

for the small units and

$$60 \times 1.75 = 105 \textit{ i.hp.}$$

for the larger one.

Unless the exhaust can be utilized for heating purposes, the compound engine will show a considerable economy over the simple engine. In the present case, the compound engine would seem to be preferable. A rough estimate makes it appear that the exhaust from the main engine will be sufficient for all heating and ventilating purposes and that the exhaust from the lighting engines will be wasted.

Tandem engines seem well adapted to the comparatively small sizes called for, and will be used in the present case. The exact dimensions will depend upon the make, but will be approximately 8 and 12x12 in. and 10 and 16x12 in. for a pressure of 120 lb., which was assumed in case of the main engine.

⁂

Detecting Ammonia Leaks

By Robert G. Thurston

Leaks are common about any refrigeration plant because of the difficulty in maintaining a system tight. If long continued, a few small leaks mean the loss of considerable ammonia which, of course, must be made up by adding a new charge. For the parts of the system not in water or brine, the writer finds that sulphur sticks are the best means for finding leaks.

Making Sulphur Sticks

Sulphur sticks may be made in several ways. The sulphur may be purchased at a drug store or of a dealer in chemical supplies, after which it remains to melt it preparatory to making the sticks. The sulphur should be put in any kind of metal can or pan and placed on an uncovered engine cylinder or on an iron plate heated by a blacksmith's forge or by a gasoline torch. If it is melted over an exposed flame, there may be trouble by the sulphur catching fire. For sticks, the writer generally uses candle wick, twisting and doubling it over once, cutting it in one foot lengths and dipping it in the molten sulphur, after which the wick is laid on a board to harden.

Another method is to dip pine sticks about the size of a lead pencil in the sulphur to within three inches from one end. Tubes of asbestos paper plugged at one end with a cork, with asbestos mortar or a piece of pipe covering, form a good mold for sticks of ½ to ¾ inche in diameter and about a foot long.

For testing, light the stick and bring it close to every joint where there is any possibility of leaks. When there is ammonia present the sulphur fumes from the stick will instantly form a white smoke indicating the leak. With a little experience one can find leaks with little trouble. To keep the sticks from burning too fast, dip them in water up to the flame; this may have to be done several times with each stick.

If the atmosphere contains much ammonia, or if there is considerable moisture in the vicinity of the leak, the inexperienced man may have trouble in finding the leak as the moisture absorbs the ammonia, making it appear that ammonia is coming from all moist parts.

Generally, if the leak is bad and the sulphur flame is brought close to it, a white precipitate is formed where the gas is escaping. As the fumes naturally flow upward, the stick should be held under and two or three inches away from the place being tested.

Leaks and joints submerged in brine or water cannot of course be tested in this way, but they may be tested with litmus paper on Nessler's solution.* If ammonia is present in water or brine it will turn the litmus paper red, while a few drops of Nessler's solution added to a sample of the brine or water will show a yellow discoloration for slight traces of ammonia, increasing to brown as the amount of ammonia increases. Litmus paper or Nessler's solution may be had from any chemist or dealer in chemical supplies or from ammonia makers.

In testing for leaks in a brine tank it is best to stop the circulation for a short time and allow the brine to become quite saturated with the ammonia.

In a double-pipe condenser, one coil should be cut out at a time; let it stand a little while and drain it, testing the water that drains out. Of course, if there are any large leaks they will show in the return water from the condenser when tested. An atmospheric condenser can be examined for leaks by testing the return water or by shutting off the water on one coil at a time until the water dries off, after which the leaks may be found with the sulphur sticks.

Water jackets on the compressor should also be tested, the same as those of the condensers and brine tanks. It is good practice to go over the whole system every week, and by so doing the result will be best noticed in the reduction of the ammonia bill for the year.

The greatest sources of ammonia loss are in the compressors, the discharge tanks, the condenser, and its valves. Expansion valves and the stop valves on the machine which are used regularly are especially likely to leak as they are operated frequently. Leaks in the discharge line are caused by variation of the temperature to which it is subjected. It is not uncommon to find the discharge line over 250 deg. when pumping out parts of the system, and, when the machine is again in regular operation, it may drop down as low as 70 or 80 deg. This naturally means that the joints are loosened more or less and leaks begin and grow. Condensers generally start leaks when they are shut down or have been running warm. The condensing water soon brings them down to the temperature of the water, and the change loosens the joints and starts the leaks. Therefore, it is good practice to shut off the water if the condenser is cut out for any length of time and let it cool down gradually.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Wheriver ye see a head, hit ut!" was Kilkenny's slogan in days of old. 'Tis a pity that some of these ancient "blue laws" are—well, you know what you'd like to do when you meet up with a sour guy stuffed full of pessimism. Be a real feller, and kid yourself that times are the best ever, even when they look at their worst. It's a good way to help make them good.

⁂

"Bud" Fisher has a muttandjeff that goes like this:

Jeff—I see they're firing on the United States battleships now.

Mutt—G'wan, you're crazy; this is a neutral country.

Jeff—I can't help that, they're firing on the U. S. ships just the same.

Mutt—Where?

Jeff—All over the world.

Mutt—Who's firing on 'em?

Jeff—The stokers.

⁂

Over a hundred mayors of the big and little cities will meet in Philadelphia soon. They have organized a utilities bureau to pull their bailiwicks out of the slough that is holding down the common people as regards their light, heat and power. When folks can get a fat little 15c. kw.-hr. dressed for the market for four or five cents, mebbe the boss will put part of the difference in our pay envelopes. Heat, light and power have a whole lot to do with our getting anywhere.

⁂

And, anyhow, the heads of our big cities are wising up to the utility of running them on sound business principles Here in New York village, a five-thousand-dollar feller got a job along the executive line through an ad in the paper. Think of it! They skipped the political high tiger spots and didn't even inquire under what emblem he voted. He was picked on his merits and had the goods. Patronage-ridden cities, please take notice.

⁂

The oil engines of war are not running to the taste of those big sea-plant engineers, U. Sam and J. Bull. As this oil is said to be standard it ought to still the troubled waters between Sandy Hook and chalky cliffs of Albion. There's a hot bearing somewhere in the political machine.

⁂

What's all this about making cotton more popular? Can't get too much of it in the power plant, even if it mostly runs to waste.

⁂

The Pennsylvania Railroad System has offered to carry free of charge to New York docks all gifts intended for the Belgian orphans and refugees of the European war. Bully! This lively little concern is always coming to the front with a shop kink that disproves the assertion that corporations have no soul or bowels of compassion.

⁂

Along in December there's going to be an international exposition of inventions in New York. It will be a show to give the inventor a show. If you have something new and useful, wrap it up and tote it in to the Grand Central Palace on Dec. 12 to 19. You can meet men with real money who will exploit it for you if it's the right kind of goods. Mebbe you are a Hargreaves, or an Arkwright or a Whitney, and don't know it.

⁂

Our old friend Mel Mix, of the Dodge Co., has again tuned his lyre to the "Safety First" madrigal. Mel hits the high C and gets away with it when he carusos that "safety first is a matter of dollars and cents," even if it does sound cold-blooded. But dollars and cents mean just as much to the boss as to the workman; it's profit and loss whichever way you regard it. And safeguarded machinery earns a big profit

⁂

Let's Mix it some more. Mr. Mix says that to be able to sell, say, power plant machinery to South America, we should first send down our buyers and put some capital in South American hands; theirs has been tied up by the war Buy something, and then you can readily sell something. Not a bit mixed is Mix; he has the right idea

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*For directions for making Nessler's solution see "Power," Mar. 31, 1914, p. 450

Chain Grates under Stirling and Vertical Boilers*

By Osborn Monnett†

SYNOPSIS—Length of grate, type of arch, extension and dimensions of gas passes, which tend toward smokeless operation. Instructions on operating a chain grate without smoke.

One of the fundamental requirements of a good setting under a Stirling boiler is that the grate should not be set flush front, but should be extended in front of the boiler sufficiently to give a good igniting action. It has been demonstrated that an ignition arch less than 5 ft. long will not show good all-around results. Taking 5 ft. as the minimum length allowable, gives an extension of from 2 ft. 6 in. to 3 ft. on this type of setting.

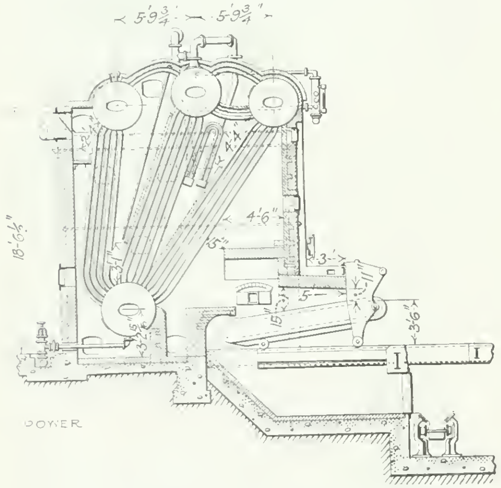

Fig. 1. Class S Stirling Boiler, 375-Hp., and Inclined Green Chain Grate

Fig. 1 shows a representative Stirling boiler setting with a 5-ft. ignition arch followed by the standard Stirling arch. This setting, which has an inclined grate, is good for normal capacities. The inclined grate works out well, not only for the Stirling boiler, but for any type of boiler, as it allows more volume under the arch for combustion. One point to be watched in chain-grate installations is the length of the grate. A short grate will give trouble on high capacities. There is a time in the life of nearly every boiler plant when it is necessary to push the stokers to the limit. When this time comes, a short chain grate will smoke badly, and will also deposit live coals in the ashpit.

Many old Stirling settings have been set flush front with short grates, using 3½-ft. arches. Such installations cannot be considered satisfactory. All things considered point to a grate with a 9 ft. 6 in. active surface (gate to water back) as the best for general use. This allows the boiler to be run at ratings up to 25 to 50 per cent. overload without distress in the furnace. With plants designed for high overloads (up to 100 per cent. overload), the grates must be longer. Fig. 2 is a typical installation with a 5 ft. 9 in. ignition arch and horizontal stoker, while Fig. 3 shows an inclined stoker without a water-back. Both of these settings are good for normal capacities.

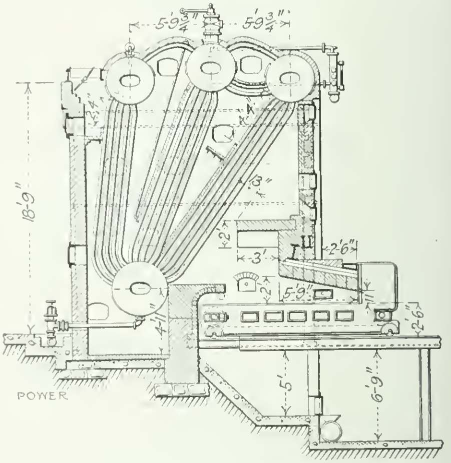

Fig. 2. McKenzie Chain Grate under 315-Hp. Class S Stirling Boiler

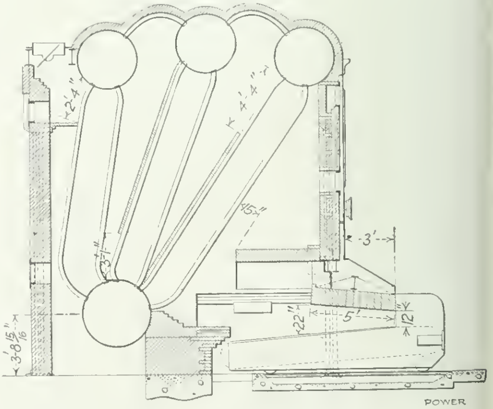

Fig. 3. Class S 500-Hp. Stirling Boiler and Laclede-Christy Inclined Chain Grate

In Fig. 4 the arch is set 15 in. high at the gate and inclines 3 in. to the foot. Fifteen inches can be taken as a good standard gate height for flat arches, as it shows much better ignition than the old standard of 11 in. There are instances, however, where the slope of the arch can be brought down to $1\frac{1}{2}$ in. to the foot with advantage. This setting easily cares for moderate swings in the load without distress, and is smokeless at all reasonable capacities. It was designed for a continuous overload of 100 per cent. The center of the mud drum is set 5 ft. above the floor line, giving room for the grate without unreasonable extension, and at the same time delivering the heat to the lower part of the front bank of tubes, so that no heating surface is sacrificed. The high-pressure water-back provides a permanent bridge-wall, requiring little maintenance expense, and the flame travel is sufficient to take care of the gases at high capacities. The following record of a test run on this unit shows that at a capacity of 941 hp. (88 per cent. overload), the efficiency was 68.1 per cent. when burning Harrisburg screenings:

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

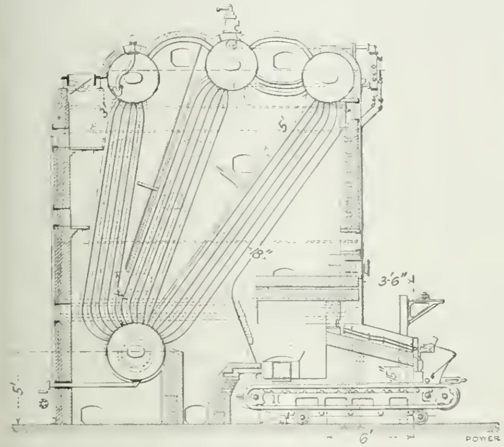


FIG. 4. CLASS O 500-HP. STIRLING BOILER AND GREEN CHAIN GRATE, DESIGNED FOR 100 PER CENT. CONTINUOUS OVERLOAD

BOILER TRIAL IN CHICAGO PLANT

Stirling boiler	7-29-14
Sq.ft. of grate surface	99
Effective heating surface, sq ft.	5016
Ratio of grate to heating surface	50.66
Factory rating in hp.	503
Method start and stop	Alternate
Duration in hours	5
Kind of coal	Harrisburg Screenings
Draft at stack, in. of water	1.35
Draft at damper, in. of water	0.59
Draft over fire, in. of water	0.42
Position of damper	Full Open
Depth of fire in inches	6
Speed of grate, in. per min.	4
Average temp. of flue gases	682
Average steam pressure, lb. gage	137
Average temp. of boiler room	84
Average temp. outside	80
CO_2 readings in per cent.	8.2
Lb. coal consumed	18,200
Per cent. of moisture in coal	5
Lb. coal consumed and corrected for moisture	17,290
Lb. coal sifted through grates and used over again	1015
Lb. ash	3310
Per cent. of dry coal to ash	19
Per cent. of coal fired, combustible	77
Lb. water evaporated	136,875
Factor of evaporation	1.187
Equiv. water evaporated f. and a. 212 deg	162,399
Lb. water evap. f. and a. 212 deg per lb. of dry coal	9.392
Lb. water evap. f. and a. 212 deg. per lb. of coal as fired	8.923
Av. hp. developed per hour	941
Lb. dry coal burned per sq.ft grate per hr	35
Lb. coal as fired per sq ft. grate per hr	36.8

CHEMICAL ANALYSIS OF COAL

Moisture, per cent.	4.84	Dry Basis
Volatile carbon, per cent	24.74	26.00
Fixed carbon, per cent	62.26	65.12
Ash, per cent.	8.16	8.58
Sulphur, per cent.	4.20	4.41
B.t.u. per pound	12,650	13,300
Boiler efficiency based on coal as fired, per cent		68.45

Another type of Stirling setting which can be adopted with advantage under certain circumstances is shown in Fig. 5. This consists of an Illinois stoker with a single arch 8 ft. 8 in. long, covering the grate entirely, set high and pitched 3 in. to the foot. On reconstruction jobs, where it is desired to improve the smoke conditions on a flush-front setting, this type of arch will work out satisfactorily for ordinary capacities. In Fig. 5, the stoker has been set with 3 ft. 11 in. extension to make sure that plenty of ignition and flame travel will be provided before the gases strike the heating surface. At the same time, the stoker is of the inclined type, which further increases the flame travel.

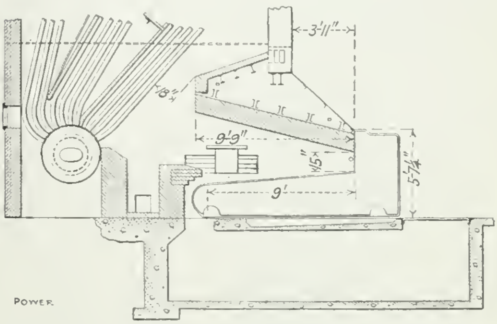


FIG. 5. A 260-HP. STIRLING BOILER WITH A SINGLE ARCH OVER AN ILLINOIS STOKER

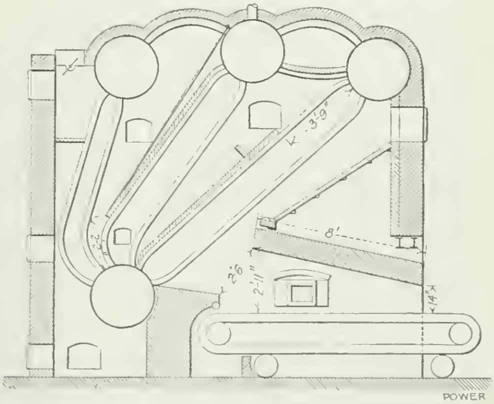


FIG. 6. STIRLING BOILER AND FLUSH FRONT STOKER FITTED WITH SINGLE ARCH

Such an arch set over an old flush-front stoker can be made to increase the steaming capacity of the boiler, provided sufficient draft is available. In overhauling an old setting of this kind, it will be necessary to look carefully to the baffles, as invariably they will be found restricted. The combination of raising the arch and making it in one span, and the opening up of the baffles, will do wonders in increasing capacity and smokeless operation on these old settings. Fig. 6 is a typical example.

The same principles apply to other types of vertical boilers, although in general the flame travel is somewhat longer. Fig. 7 shows a chain-grate setting under a 312-

hp. Erie City vertical boiler, in which the ignition arch is 6 ft. long, with a secondary step-up flat arch of the same length. The flame travel here is ample to provide smokeless operation at any commercial capacity, and the total extension is 10 ft. 6 in. to the gate.

In combining a chain grate with a boiler of the Wickes type, ample flame travel can be provided, and the arch can be set at a height corresponding to the capacity it is desired to obtain and according to the draft which will be available. Ordinarily, an extension of 13 ft. from the heating surface to the gate will be found sufficient for a 400-hp. unit such as is shown in Fig. 8.

HOW TO OPERATE A CHAIN GRATE WITHOUT SMOKE

Starting Fires—Feed in the coal until the grate is about half covered and the hopper is empty. If the hopper is fed by a chute, care should be taken not to let down too much coal at this time. When all the coal has passed under the gate, throw some fresh coals from another fire or some light wood kindling with a few pieces of waste on the coal and start a fire. Sprinkle a little coal over the fire at the gate and feed in slowly until the fire is inside of the gate, and let the stoker stand for a few minutes until all of the coal is ignited. This with the damper partly open. Then fill the hopper with coal through the chute and let the stoker run slowly until the arch gets heated up, after which the regular speed can be used with the damper wide open.

Carrying the Load—Adjust the thickness of the fire at the gate until the whole of the grate is covered. The average speed of the grate ought to be about 3½ in. per min. If live coal goes into the ashpit, run the fire thinner or slow down the stoker. Do not allow the back end of the grate to become bare of live coals, as it will interfere seriously with efficiency. Proper manipulation of the speed and of the gate will keep the grates covered. Do not become alarmed if a few incandescent particles drop into the ashpit. It will not affect the economy.

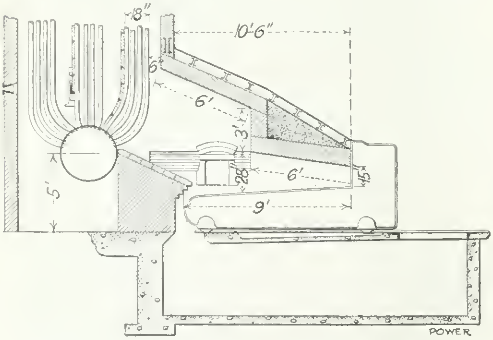


FIG. 7. AN ERIE CITY 312-HP. VERTICAL BOILER AND INCLINED ILLINOIS CHAIN GRATE

To prevent clinkers from attaching to the side of the furnace, run a slice bar in along the sides occasionally.

Banking Fires—Let the fire burn short, raise the gate high and run in a heavy fire for two or three feet, according to the length of time the bank is to be carried. In doing this, run the hopper empty, lower the gate and partly close the damper.

Starting After a Bank—Raise the gate, break up the bank with a hook, pulling some of the fire out into the hopper. Lower the gate, fill the hopper with coal and start the stoker slowly with partly opened damper until the arch gets hot. Closing the damper with a heavy fire on a chain grate will cause smoke, therefore if the demand for steam slackens, never close the damper until the fire has burned off the greater part of the volatile matter from the coal. Never stop the stoker for any length of time without first running the hopper empty, as the fire will burn back and injure the gate.

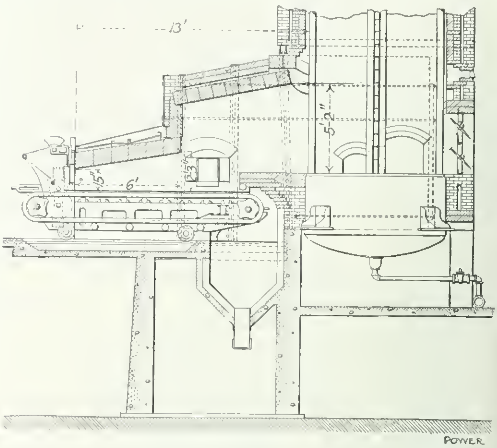


FIG. 8. A GREEN CHAIN GRATE UNDER A 400-HP. WICKES BOILER

Errata—In the article "Chain-Grate Setting—II," of the Oct. 20 issue, Figs. 7 and 9 were transposed. The boiler in Fig. 7 is a Geary and that in Fig. 9 is an Erie City.

⁂

Cleaning the Caps of Water-Tube Boilers

After the caps on the headers of water-tube boilers have been removed for cleaning purposes, it is often hard to put them back again so that they will not leak. The difficulty is to get a tight metal-to-metal joint between the caps and the headers, as the slightest irregularity or unevenness holds the two surfaces apart sufficiently to cause leakage. It is common practice to endeavor to make the surfaces fit each other by smoothing them off with emery cloth. In doing the work it is convenient to tack the emery cloth upon a wooden disk, which is then made to revolve in a lathe or on a special machine constructed for the purpose, the cap being pressed up against the emery for a few moments until the surface is cleaned. The nuts may be treated in the same way.

The main objection to this procedure, apart from the necessity of frequently renewing the covering of the disk, is that the cap wears down at the outer edge faster than it does along the inner one, and hence it becomes rounded to a slightly convex shape, so that it will not touch the header anywhere except along a narrow line close to the inner edge. As a result, the contact is so poor that it is always hard, and sometimes impossible, to make the joint tight; and in the effort to stop the leakage the men sometimes screw the nuts up hard enough to strip the threads.

This trouble may be readily overcome by the following method, which is both simple and effective. A cast-iron faceplate is first prepared by resurfacing it in a planer. A mixture of oil and emery is then smeared over the faceplate, which is afterward revolved on a spindle, the cap to be treated being held up against it. In this way the cap can be ground down to a satisfactory surface, easily and quickly. If it does not become satisfactorily flat and true on the first application, it will be materially improved, and after the caps have been treated a few times they will fit the headers quite well. The object of finishing the faceplate on a planer is to provide it with a series of small, straight, shallow, parallel grooves, running across its surface from side to side. These serve to hold the emery and oil, so that a far better grinding action is obtained than could be had if the faceplate were smooth. No attempt should be made to exaggerate the tool marks, because they will usually be quite deep enough without doing so. Grooves turned in the faceplate on a lathe would not be useful for the purpose in mind, because they would run circularly around the plate, and therefore would not hold the emery and oil up against the cap satisfactorily. The ideal way to treat the plate would be, to provide it with shallow *radial* grooves; but the planing operation is far simpler, and it works quite well.

The same idea may be applied, if desired, to clean and true up the face of the header, where the caps rest against it; but in this case a special portable machine, operated by a motor of some kind or attached to a flexible shaft, must be used for rotating the grinding plate in contact with the header.—*The Travelers' Standard.*

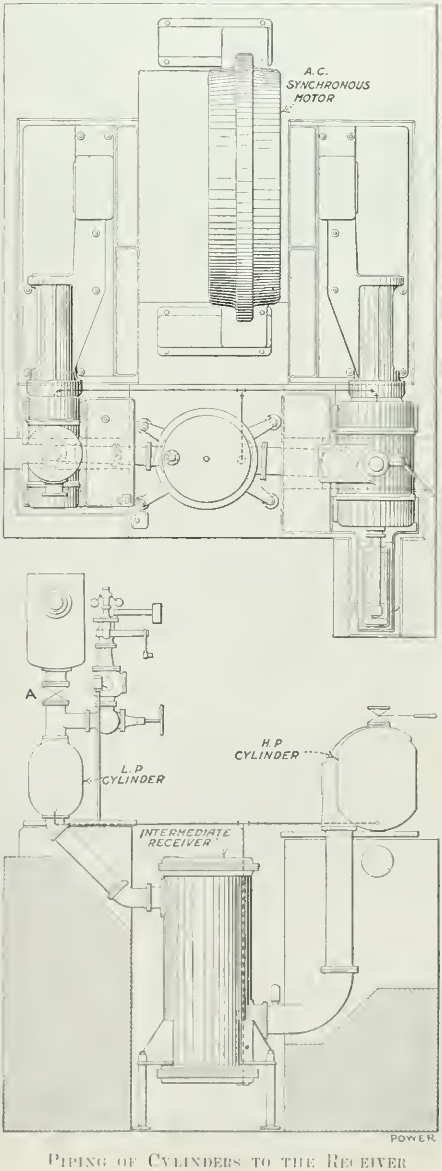
Air Compressor or Steam Engine

While at the works of the Nordberg Manufacturing Co. recently, the writer saw a two-stage air compressor almost ready for shipment to the Canadian Mining & Finance Co., of Timins, Ont. It was a standard machine, cross-connected, with the usual mechanically operated Corliss valves, having cylinders 22x37x31 in. The compressor is to be driven by a 25-cycle synchronous motor at 125 r.p.m. The unusual feature is that the machine is to be used as a steam engine in case of necessity, this being possible with the type of valve employed on Nordberg compressors.

It appears that the mining company operates the mine electrically, current being purchased from an outside water power. The principal equipment consists of a mine hoist, underground pumps, a concentrating mill, a compressor duplicating the one mentioned and a third compressor of different make. To guard against a possible breakdown in the transmission line, a steam reserve plant was considered necessary. Ordinarily, a full equipment of boilers, engines and generators would be needed, but with these compressors only the boilers are to be installed. Steam may be turned into the high-presure cylinder of the compressor, then delivered to the intermediate receiver and thence to the low-pressure cylinder as in any Corliss engine. The operation will be the reverse, the motor turning in the opposite direction will act as a generator. With a slight adjustment of the valves, the economy will be nearly as good as of an engine designed for the work.

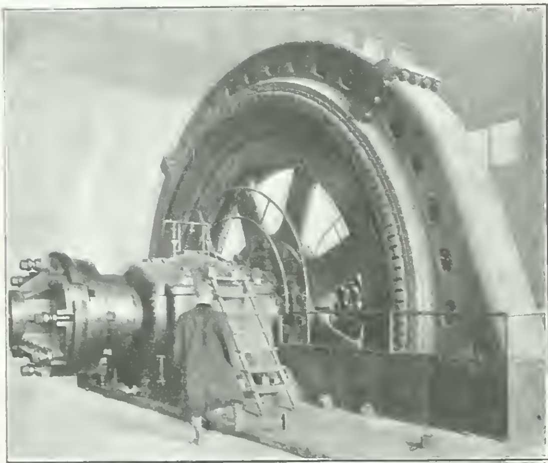
To control the steam supply there is an automatic cutoff governor operated by an eccentric and also a belt from the crank shaft. The governor regulates the quantity of steam to the angle throttle valve connected to the discharge pipe of the compressor between the high-pressure cylinder and the receiver, as shown in the illustration. When steam is being supplied, the valve *A* is closed, and the same is true of the angle valve when the machine is acting as a compressor.

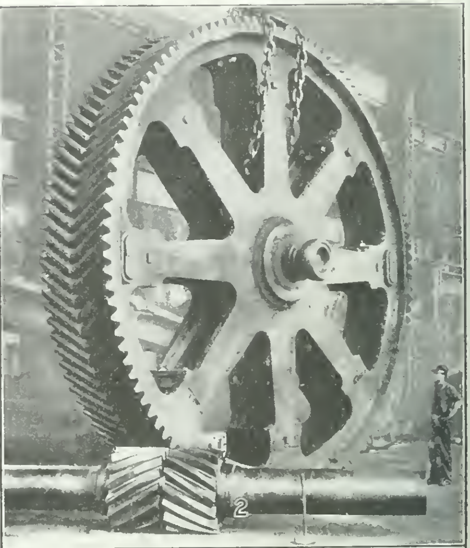
By this arrangement, enough current is generated to run the mine at reduced capacity and maintain it in operation until service from the water power is resumed.

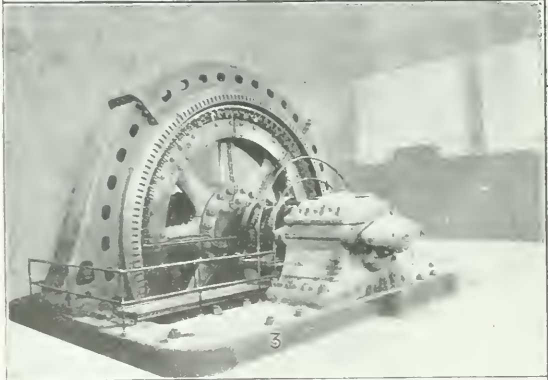


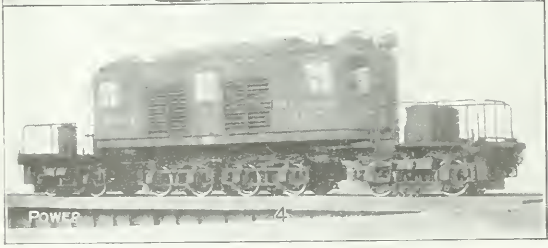
Piping of Cylinders to the Receiver

Some Large Apparatus









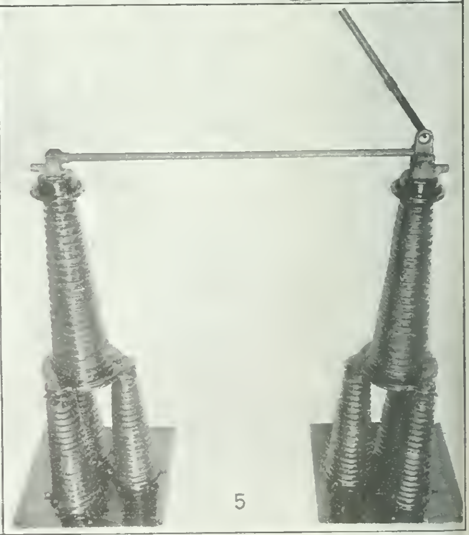


Fig. 1. this 6000-hp., 36-pole, 6600-volt induction motor drives an 18-in. continuous-billet mill at the Indiana Steel Co.'s plant, Gary, Ind. It has a speed of 83 r.p.m. Fig. 2, a 232-in. pitch diameter William Tod Co.'s gear with 116 teeth, 42-in. face. The pinion is of 30-in. pitch diameter, 15 teeth, and has a 42-in. face. It is forged and carries two 13-ft. 6-in. flywheels weighing 50 tons. The total weight of the gear and pinion is 85 tons. This is the largest gear with machine-cut double-helical teeth ever made in this country. The helix is at a 30-deg. angle. Fig. 3 is a 6500-hp., 6600-volt induction motor of the slip-ring type. It is provided with a switch for changing the number of poles to change the speed. The motor may be run as a 28- or 56-pole machine with speeds respectively of 107 and 53 r.p.m. It is used in the 60-in. universal plate mill of the Indiana Steel Co.

Fig. 4 is a 100-ton electric locomotive built for service on the electrified section, the Hudson division, of the New York Central & Hudson River R.R. Ten of these have been ordered. This is the most powerful electric passenger locomotive ever built, and will exert sufficient tractive effort to haul a train weighing 1000 tons at a speed of 60 miles an hour.

Fig. 5 shows a 150,000-volt, 300-ampere disconnecting switch with corona caps and tubular blade. The height of the switch is 5 ft., 11 $\frac{11}{16}$ in. The distance between the centers of the top insulators is 4 ft. 8 in. This apparatus, with the exception of the gear and pinion, is the output of the General Electric Co.

Steam Engineers' License Law of Detroit Amended

The common council of Detroit recently adopted an amendment to the steam engineers' license law as proposed by J. C. McCabe, chief boiler inspector. The amendment provides for free annual renewal of licenses. Under the newly amended ordinance all applicants for license must pay a fee of $1 when making application. If they pass the required examination and are awarded a first- or second-class license, they must pay an additional fee of $2. If a third- or fourth-class license is obtained the extra fee is only $1. All licenses are renewed without charge if application for renewal is made within 10 days after expiration. Formerly there was a renewal fee.

There are about 2700 licensed engineers in Detroit, of which some 2000 will benefit by the free-renewal amendment. About 1200 applications for licenses are received each year.

An ordinance has also been passed to regulate the use, handling, storage and sale of inflammable liquids. Detroit is the first city to pass such an ordinance, which closely follows the code of the National Board of Underwriters. Mr. McCabe, the chief boiler inspector, is to have charge of the inspection of all devices used in the storage and handling of these liquids.

*

York Power Companies Merge

The City Council of York, Penn., has consented to the merging of the Merchants' Electric Light, Heat & Power Co. with the Edison Electric Light Co. The latter company has applied to the State Public Service Commission for a certificate of approval.

The Merchants' company will forfeit a $5000 bond to the city, this being one of the provisions in its charter. For years these two companies have been rivals in York and the vicinity. The field is now controlled by the Edison company.

*

Goes Perpetual Motion One Better

The following clipping from the *Kansas City Post* of Sept. 5 should interest power-plant men:

> An engine that runs itself on its own power, developing energy to operate machinery, has been invented in this city. The inventor has been working for five years on his self-operating engine, and now has it near perfection. A few alterations are to be made. These will increase its efficiency.
>
> The engine is run by compressed air, making its own pressure as it runs. The exhaust from the cylinders returns through a series of eight-port automatic valves, to a large steel pressure tank. This tank is a double affair, there being a smaller tank within the larger one.
>
> An air space of 6 in. intervenes between the two tanks. Into the air space the exhaust from the cylinders is forced, the action being such that the nitrogen gases are separated from the oxygen and, forming a lighter gas, rises to the top of the tank, at the same time creating a pressure which forces the fresh air down through the inner tank and back into the engine, which is operated by this pressure.

The only serious feature of the foregoing is the fact that men do actually attempt to get something for nothing, mechanically.

*

Electricity in the Steel Industry—The magnitude of electrical application in the iron and steel industry is not without interest or surprise. The data show that the installed horsepower of motors used last year by 62 steel companies was more than 1,250,000 and the number of motors in service was 45,512. More startling was the amount of energy generated and purchased by these companies, 1,611,564,000 kw.-hr. This is more than one-tenth of the total output of the central stations of the United States in 1912, and the rating of motors is almost equal to that receiving energy from the entire central-station industry of the country seven years ago. One plant alone used more electricity than was generated by the Edison systems of Brooklyn and Boston combined. When, as has been predicted, electricity shall have supplanted steam entirely as motive power, the electrical needs of the steel industry will be enormous. Only three of the companies purchase electrical energy. An abundant opportunity exists here for enterprising central-station managers to add to this number.—"Electrical World."

Carnegie Institution Reorganizes Stationary Engineering Department

The School of Applied Industries of the Carnegie Institute of Technology offers a course in the theory and practice of power generation, which covers the operation of steam engines, steam boilers, gas engines, electric generators, motors and all auxiliary apparatus. While this department has been in existence for several years, it has recently undergone a reorganization for the purpose of increasing its efficiency and effectiveness in meeting the growing demand for instruction of this nature.

Not only is a straight night course offered, but a special course has been arranged to benefit the man who alternates day and night turn. This is special only as regards time, and is identical in every way to the regular night course. It will allow the engineer to attend school six to eight hours per week on his off turn. It will also allow any engineer, employed at night only to attend school for a short period of six to eight hours per week, during the day.

As far as is possible and practicable, students are instructed from actual engines, boilers, and models. Mathematics is eliminated or simplified in demonstrations, at the beginning of the course, and later taken up as the student gains knowledge of this important subject.

There are available for demonstration and test five different types of boilers, from 60 to 350 hp.; five different types of steam engines, from 10 to 750 hp.; nine different types of internal combustion engines, from 1½ to 550 hp.; in addition to a large variety of auxiliary apparatus. All of these, with the exception of one gas engine, are located in the new Machinery Hall.

The course is laid out to cover a period of four years, and consists of work on the above mentioned equipment, accompanied with numerous lectures and problems. Other subjects given during the four years are mathematics, drawing, machine shop practice, elementary electrical engineering, chemistry, and English.

No written examination for entrance to this course is required, but each applicant must present himself to the dean of the School of Applied Industries for personal interview, and must show satisfactory evidence of his natural ability and tendency for work of this nature. Preference will always be given to men already employed in some power station.

A student registering under this alternate day and night arrangement, as well as for the regular night class, shall do so as a regular night student. The total tuition for night courses is $16 a school year for residents of Pittsburgh, and $18 for non-residents.

Engineers will be gladly furnished any further information by the registrar, Carnegie Institute of Technology, Pittsburgh, Penn.

*

Arkansas Power Co. Expands

The Arkansas Light & Power Co. is planning extensive improvement, and in order to finance these it has filed a mortgage in favor of the Guaranty Trust Co., of New York, securing payment of its two-year 6 per cent. notes. It is specified that the latter are not to exceed $1,000,000.

The company operates plants at Malvern, Camden, Arkadelphia, Magnolia and other points in the state. It will not only improve its present plants, but will add to the number, and is considering the advisability of erecting a power dam at Caddo Gap.

*

Pacific Coast Power Notes

The quarterly report of State Engineer Lewis of Oregon, just made public, shows 173 permits issued for the appropriation of water for power purposes. These permits cover works to cost $5,000,000 in the development of 30,160 hp., constructing 230 miles of pipe lines, etc.

George W. Holcomb, Portland, Ore., proposes to develop 10,255 hp. from the Clackamas River, the Rogue River Public Service Corporation contemplates the development of 11,989 hp. on the Rogue River and J. E. Johnson, Drewsey, has secured a permit to develop 3409 hp. with the waters of the Malheur River. The Siletz Power Co., Portland, Ore., has a filing on the Siletz River for the development of 2576 hp.

Plans are being prepared under the supervision of Major J. B. Cavanaugh, Seattle, for the construction of a $50,000 power house for the Lake Washington Canal project of the War Department. There are also plans for the construction of five operating houses and twenty 30-ft. reinforced-concrete light standards for the canal locks.

A reorganization of the Yosemite Power Co. has been made at Sacramento, Calif., by the consolidation with the Tuolumne Light & Power Co., the Tuolumne Water Co. and the La Grande Water Co.

Recent Court Decisions

Digested by A. L. H. STREET

Damages Recoverable for Personal Injury—$4900 was not an excessive award for injury to an employee of a power company, sustained by him in consequence of negligence imputable to the company, where it appeared that he was 23 years old, had previously earned $2 a day, lost the sight of one eye as a result of the injury, and had the sight of the other eye impaired, according to a recent decision of the Maine Supreme Judicial Court handed down in the case of Rollins vs. Central Maine Power Co., 91 "Atlantic Reporter" 937.

Duty to Maintain Water Glass—An employer's negligent failure to replace a broken water glass on a stationary boiler after being informed of the break may be found to be the direct cause of death of the fireman, caused by explosion of the boiler, although the latter could have determined the stage of the water in the boiler by using water cocks with which the boiler was equipped. "Where machinery is equipped with more than one safety appliance, and one of these appliances is better adapted to use by unskilled persons than the other, it is the duty of the master to use reasonable care to keep all of the appliances in working order, so that the servant may have all the protection that the conditions surrounding him reasonably permit. And the reasonable presumption is that an employee like Moreland (the fireman) would depend on the water glass more than on the water cocks." (Moreland's Administratrix vs. Hough & Spradlin, 169 "Southwestern Reporter," 467, Kentucky Court of Appeals.)

NEW PUBLICATIONS

FUEL ECONOMY AND CO_2 RECORDERS. By A. R. Maujer and Charles H. Bromley. Published by McGraw-Hill Book Co., New York. Cloth, 189 pages; 8¼x5½ in. Price, $1.50

The contents of this book first appeared in the "Engineers' Study Course" in "Power." The aim of the authors has been to give to practical operating men a simple yet reasonably thorough treatment of the subjects of combustion, coal analysis, flue-gas analysis, heat losses, draft, boiler testing, feedwater treatment and CO_2 recorders.

That the "Study Course" was so well received would indicate that the book will fill a want long felt by the progressive operating engineer seeking to better his boiler-room conditions.

PRACTICAL MATHEMATICS FOR ENGINEERS. By F. Hoovenden. Published by D. Van Nostrand Co., New York. Cloth; 144 pages. 5½x8 in. Price $1.

This book is intended chiefly for marine engineers and apprentices following marine engineering. As the book was written in Great Britain, the money values, etc., used are English; the text aims to coach the student for a Board of Trade certificate.

Beginning with numbers, the subject is followed, as in the usual arithmetic through to mensuration. Pages 98 to 134 are devoted to problems in mechanics, the nature of the problems being associated almost exclusively with marine engineering. The last few pages contain answers to many of the problems given.

HIGH-POWER GAS ENGINES. By H. Dubbel. Translated from the German and expanded by F. Weinreb. Published by D. Van Nostrand Co., New York, 1914. Size 7½x11 in.; 197 pp.; 436 illustrations. Price $5 net.

This is a book intended essentially for the designer. As such, much of the elementary and general matter usually found in gas engine books has been omitted and the text devoted to the special problems encountered in the large gas engine. German practice predominates, as might be expected, not only from the origin of the book, but because the Germans have been pioneers in developing the large gas engine. This is supplemented by present English practice and a few American designs. The illustrations are good and assist greatly in a clear understanding of the text.

INDICATOR DIAGRAMS FOR MARINE ENGINEERS. By W. C. McGibbon. Published by D. Van Nostrand Co., New York. Third edition. Imitation leather. 182 pages; 9¼x8 in.; indexed, with list of illustrations. Price, $3.

For marine engineers this is the best work on the indicator that has come to our attention. The author has met his endeavor to give a complete treatment of the subject and at the same time avoid elaborate mathematical calculations. It is sufficient to say that the book does not neglect any important phase of steam-engine indicator practice, and this may be appreciated when it is known that there are 159 illustrations, mostly of diagrams thoroughly considered. The diagrams appear in white on a black background.

The marine engineer will find this a most useful book.

ELEMENTARY MATHEMATICS FOR MARINE ENGINEERS. By J. W. M. and R. M. Sothern. Published by D. Van Nostrand Co., New York. Cloth. 174 pages; 5½x8 in. Price $1.

The field of this book is fully told in the title. The volume starts with elementary algebra, the first seventy-six pages being devoted to this subject, giving it a reasonably thorough treatment. Logarithms follow. The third section is rather unusual for a book on elementary mathematics for practical men, in that it is devoted to a study of entropy.

The author covers the subject well for the purpose and, of course, finds many opportunities to put to use the student's knowledge of logarithms as offered by the previous chapter. There are nineteen temperature-entropy diagrams, including three which are large and inserted so that for the principal problems diagrams are shown and assist the student in following this much disliked subject. The last chapter is a short treatment of plane trigonometry.

A dollar is a fair price for the book, and a marine engineer especially would not regret the investment.

HEAT ENGINES. By John R. Allen and Joseph A. Bursley; second edition. Published by the McGraw-Hill Book Co., New York, 1914. Size 6x9 in., 320 pp.; 185 illustrations. Price $3.

The scope of this book is somewhat broader than might be inferred from the title, including heat, elementary thermodynamics, properties of steam, calorimeters, combustion and fuels, boilers, auxiliaries, steam engines, valve gears, governors, condensers and air pumps, steam turbines, gas engines and oil engines. Limitations of space have precluded a special study of any of these subjects, but enough is given to afford the reader a general working knowledge of each. Bearing in mind its purpose, namely, a textbook for engineering students, it appears to meet the requirements, and, however, is one of the few college textbooks suited to outside study without the aid of the instructor. For such use, the small amount of higher mathematics contained in the text need not prove a serious obstacle. A number of practical examples at the end of each chapter add to a clearer understanding of the subjects discussed.

In revising the book the authors have rewritten much of the text, brought up to date the chapters on steam turbines and gas engines, and added descriptions of such later subjects as the uniflow engine and the Humphrey pump.

Small Charge for "Consular and Trade Reports"—The Department of Commerce has announced that to meet the constantly increasing demands which were far in excess of the edition authorized by Congress for free distribution, a subscription price of $2.50 a year was fixed for the "Daily Consular and Trade Reports," effective July 1, 1914. Under this plan the charge, which is less than the cost of printing and paper, permits all firms and individuals who desire the publication to obtain it promptly. Many persons who were formerly unable to obtain the reports because of the limited edition fixed by law, may not yet be aware of the opportunity to subscribe, and thus have access to the commercial information gathered by the Federal Government from all the countries of the world for the benefit of American business houses. Subscriptions for the publication are received by the Superintendent of Documents, Government Printing Office, Washington, D. C., at $2.50 per annum mailed daily, and $6 per annum for cloth-bound quarterly volumes, with index.

ENGINEERING AFFAIRS

Boston Edison Co. Annual Meeting—The annual meeting of the Boston Edison Co. Section of the National Electric Light Association was held in the assembly hall of the Engineers' Club, Tuesday evening, Oct. 20, at 8 o'clock. A lecture of special interest to members, on "The Hydraulic Plant of the Mississippi River Power Co. at Keokuk, Iowa," was given by H. T. Edgar, of the Stone & Webster Corporation. On the completion of the lecture, stereopticon illustrations of the plant were shown by D. L. Galusha, of the same corporation.

POWER

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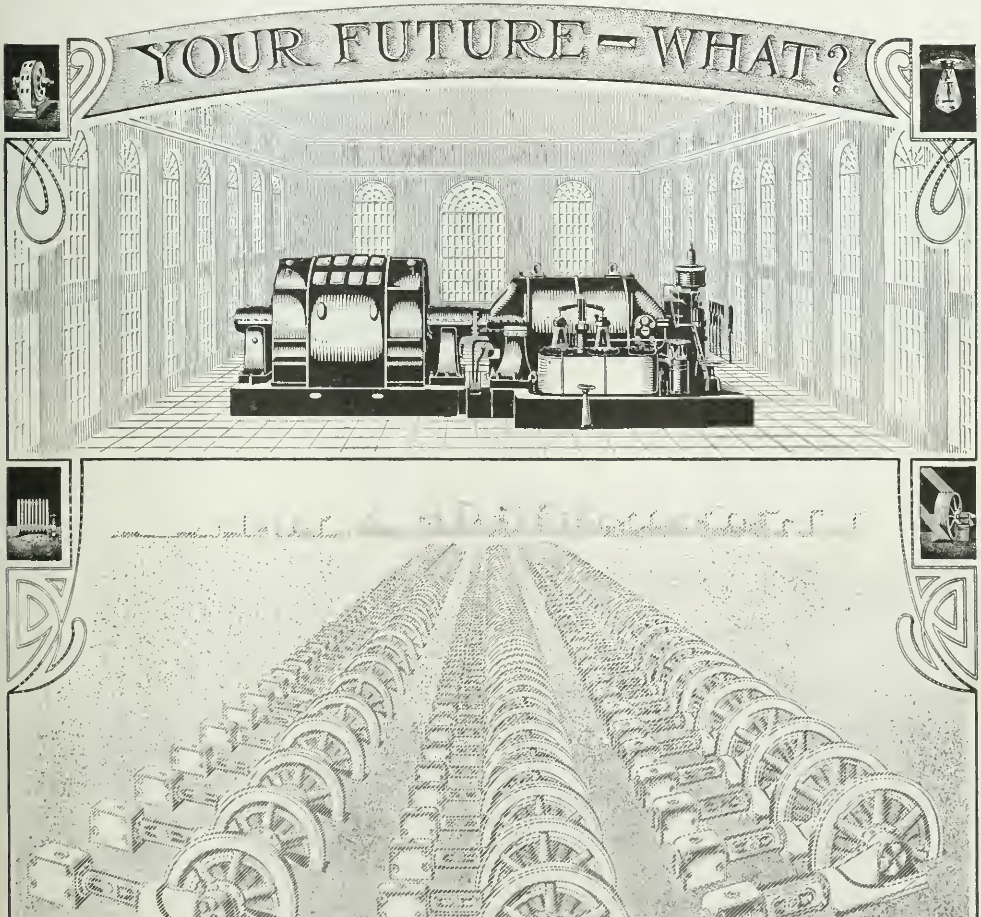

The Capacity of this 20,000-Kw. Turbine is More than equivalent to that of 184 Engines of 150 Hp. Each. Is your plant liable to be absorbed?

Seaview Hospital Plant

By A. D. Blake

SYNOPSIS—A 675-kw. plant supplying 240-volt, two-phase current for power, 110-volt, single-phase for lighting and 240-volt, single-phase for special heating service. Both exhaust and live steam are used for general heating. Refrigeration is supplied by a carbonic anhydride system.

⁂

Seaview Hospital, recently completed by the Department of Public Charities of the city of New York for the care of its tubercular patients, occupies a site on Todt Hill, one of the highest points on Staten Island, and in fact on the Middle Atlantic coast. It consists of seven five-story ward buildings arranged in a crescent (see Fig. 1) and connected by covered passages with a kitchen, an administration building, an operating pavilion, a nurses' home and a staff house. A central power and heating plant serves the group through a series of pipe tunnels.

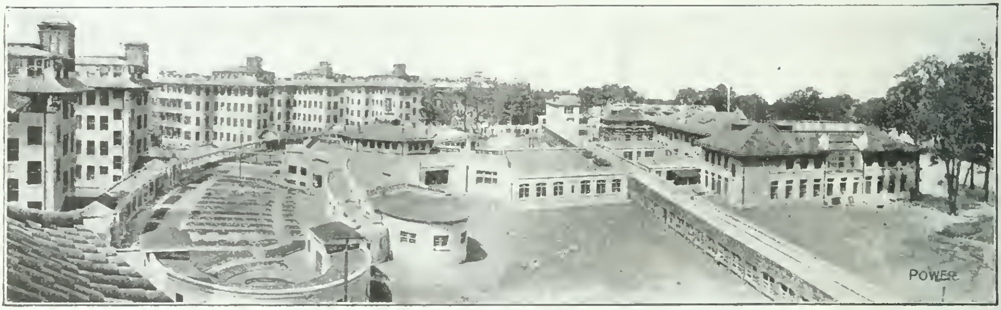

Fig. 1. General View of Hospital Group with Power House in Background

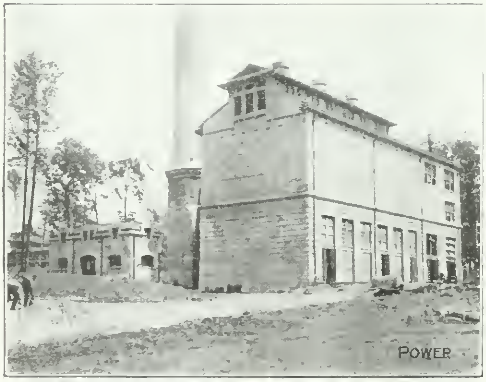

Fig. 2. Power House

As shown in Fig. 2, the power house is of reinforced-concrete construction, with Spanish tile roof and trimmings to correspond in architecture with the other buildings.

When the plans for the institution were first considered, some differences of opinion existed as to the advisability of installing a generating plant or of purchasing electricity from the Richmond Light & Railway Co. The service of the local company at that time, however, was most unsatisfactory and, as all overhead distribution is employed, summer thunder storms often seriously interfered. Aside from the economic aspects of the case, it was imperative that there be uninterrupted service in the operating rooms, which fact was largely responsible for the decision in favor of an independent plant.

Although entailing a somewhat greater cost, a two-phase, four-wire, alternating-current system was selected in preference to the three-wire, direct-current. The chief argument in favor of the alternating-current system appears to have been the desire to render the equipment operative from the breakdown service of the local company.* This has since been disconnected as there is sufficient reserve capacity to insure uninterrupted op-

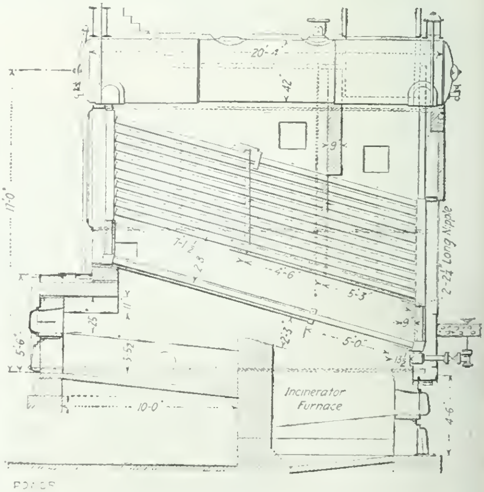

Fig. 3. Section through Special Boiler Setting, Showing Incinerator

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*This company is now planning to change over its system to three-phase.

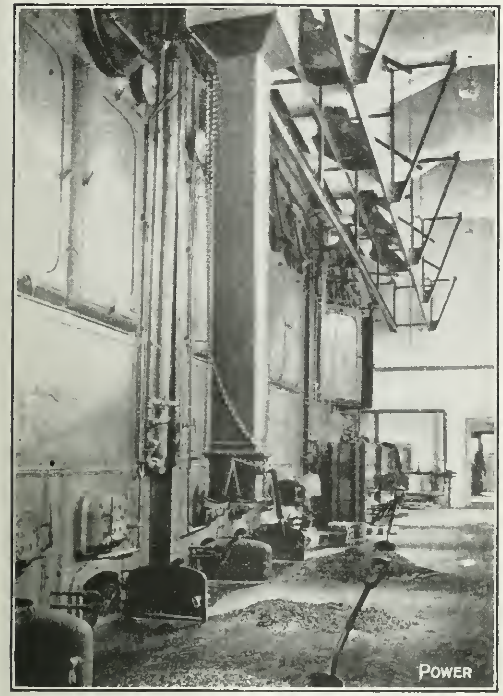

Fig. 4. Boiler Room

eration. Before being taken out, however, it did serve for a period of several weeks as a breakdown for the lighting company. This was during the time the Livingston station was badly crippled from a boiler explosion and the hospital plant supplied electricity to a large section of the island.

Boiler-Room Equipment

Steam is furnished at 125 lb. by five 364-hp., B. & W., hand-fired boilers set in a row, in batteries of two, and one single. In order to dispose of the large amount of refuse incident to hospital work, it was believed that the regular boiler plant might be utilized, and accordingly, one of the batteries was provided with a special setting with the boiler fronts extended and an incinerator furnace at the rear, as shown in Fig. 3. With this arrangement it will be noted that both horizontal and vertical baffles are employed. However, the setting has not proved altogether satisfactory in actual operation and it is understood that alterations are contemplated.

In order to burn the anthracite coal freely, under ordinary conditions without forcing, ample grate area has been provided for all the boilers, the grates being 8 ft. 6 in. by 10 ft. long, thus making an area of 85 sq.ft. and a ratio of heating surface to grate surface of about 43 to 1. There are blowers for forcing the fires when necessary.

The flue gases discharge through a breeching at the rear of the boilers to the stack, which is independent of the boiler house. This stack is of reinforced concrete, 175 ft. high and 8½ ft. diameter at the base, representing an area of 0.031 sq.ft. per boiler horsepower and a ratio of stack area to grate area of 1 to 7½.

Over the boilers is a 1400-ton coal bunker which discharges through an automatic weighing hopper and chute to the aisle in front of the boilers. The coal is carted to the plant by automobile trucks from Port Richmond, a distance of about three miles, and is dumped in a hopper from which it is elevated by a motor-driven bucket conveyor to the storage bunker. No special means have been provided for handling the ashes, it being necessary to remove them through the ash doors at the boiler fronts, thence through the boiler room.

There are three 7½ and 4½ by 10-in. duplex boiler-feed pumps supplemented by two injectors, and one open feed-water heater utilizing the exhaust from the auxiliaries, and capable of heating 45,000 lb. of water per hour from 70 to 210 deg. A venturi meter is placed in the feed line.

The boiler feed pumps, hotwell pumps and vacuum pumps are situated in a pit between the engine and boiler rooms.

Steam from the boilers is supplied by two lines, a main and an auxiliary, which come up through the engine-room floor and terminate in a riser to the overhead line from which long-radius branches lead to the throttles of the individual units. This is shown in Fig. 5, the riser being just back of the oil tank.

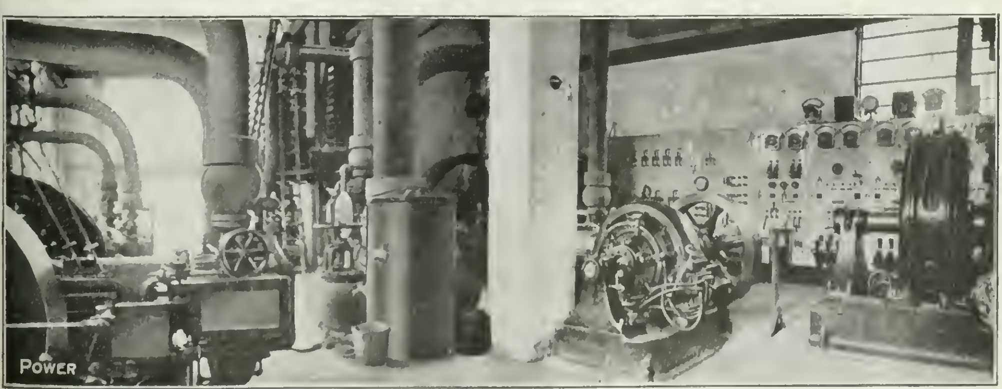

Fig. 5. Engine Room, Showing Generating Units

Main Generating Units

These consist of three 18 and 28 by 14-in. angle-compound engines directly connected to 200-kv.a., two-phase, four-wire, 60-cycle, 230-volt generators, and a smaller unit comprising a 12 and 19 by 10-in. angle-compound engine driving a 75-kv.a. generator. The larger units run normally at 257 r.p.m. and the smaller one at 300 r.p.m. Excitation at 125 volts is furnished by two 22-kw., engine-driven exciters.

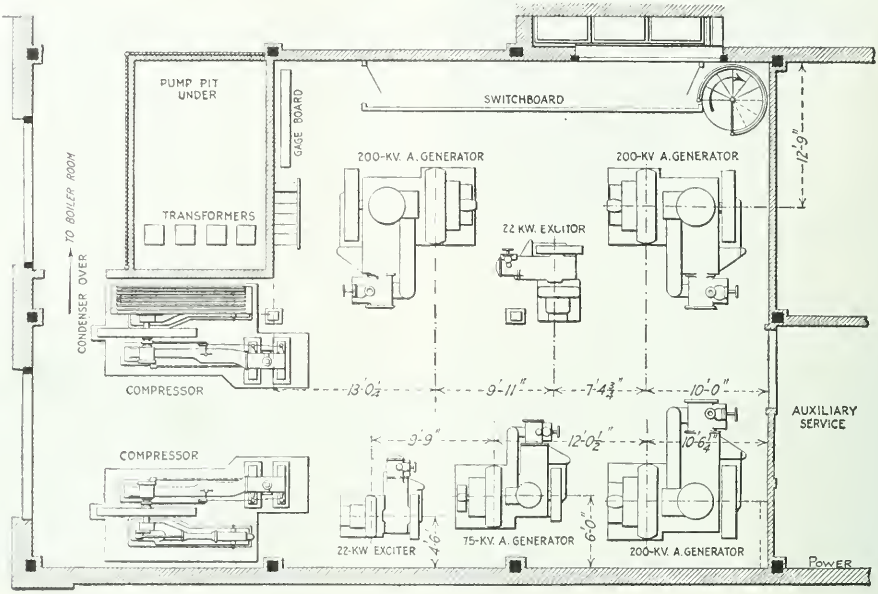

Fig. 6. Plan of Engine Room

The large units were purchased on a steam consumption guarantee of 22, 24 and 29 lb. of steam per horsepower-hour when running at full, three-quarters and half loads, respectively, under a steam pressure of 125 lb. and a back pressure of 3 lb. The guarantee for the smaller unit under like conditions was 23, 25 and 30 lb.

As is apparent from Figs. 5 and 6, the engine room is badly crowded: in fact, some of the units, particularly the CO_2 compressors, are so placed as to render them almost inaccessible, and in two places it was found necessary to cut holes in the wall, in order to get at the valves. One explanation that has been offered for this crowded condition is that turbines with fewer units were originally contemplated and the room laid out accordingly.

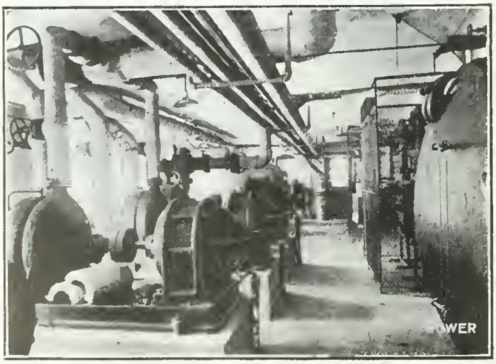

Fig. 7. Service Pumps

Heating System and Auxiliary Service

The engines exhaust into a 14-in. exhaust main, which carries steam for heating to the various wards and other buildings. The returns from the heating system are under a vacuum and discharge into the hotwell, from which they are pumped to the heater. A small plunger pump handles the drips.

Live steam at 80 lb. is supplied to the kitchen, laundry and wards, in the latter for sterilizers and food warmers. With approximately 150,000 sq.ft. of radiation, the heating demand in cold weather is far in excess of the exhaust-steam supply and considerable live steam is necessary. However, it is planned to take over the lighting and power load of the Farm Colony adjacent to the hospital, which will help to equalize the exhaust-steam supply and demand.

The ward heating is laid out on the basis of one square foot of radiation to 19 cu.ft. of space. This extremely low ratio was decided upon to meet the peculiar considerations of the service. While it is desirable to have the wards comparatively cold at night, with plenty of fresh air from the outside, it is necessary that they be heated up quickly in the morning so that the convalescent patients may have warm rooms in which to dress.

Cold-water service to the various buildings is supplied by two motor-driven centrifugal pumps, which deliver into two large tanks under an air pressure of from 50 to 60 lb., this air being furnished from an air tank which, in turn, is supplied by a locomotive-type air compressor.

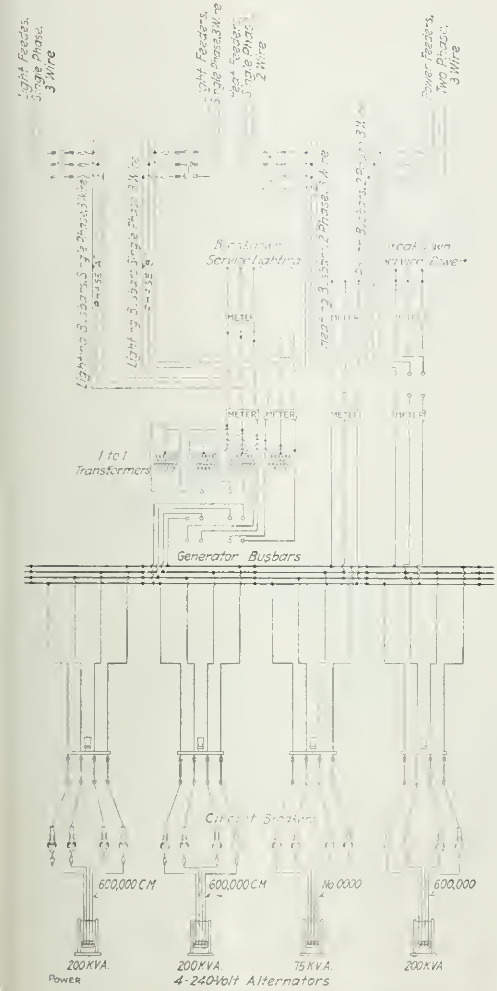
Light Feeders, Single Phase, 3 Wire
Light Feeders, Single Phase, 3 Wire
Heat Feeders, Single Phase, 2 Wire
Power Feeders, Two Phase, 3 Wire
Lighting Busbars, Single Phase, 3 Wire, Phase A
Lighting Busbars, Single Phase, 3 Wire, Phase B
Heating Busbars, 2 Phase, 3 Wire
Power Busbars, 2 Phase, 3 Wire
Breakdown Service Lighting
Breakdown Service Power
METER
METER
METER
METER
METER
METER
1 to 1 Transformers
Generator Busbars
Circuit Breakers
600,000 CM
600,000 CM
No 0000
600,000
200 KVA.
200 KVA.
75 KVA.
200 KVA.
4-240 Volt Alternators
POWER

Fig. 8. Diagram of Electrical System

The motors driving the pumps are of the wound rotor type and operate automatically through a float control. Since the water level in the tanks is maintained automatically, the drop in air pressure is very slow, hence hand control is employed for the compressor.

Hot water is furnished by two closed heaters, having both exhaust- and live-steam connections and supplying two small motor-driven centrifugal pumps, which circulate it to the various buildings. The water is maintained at about 140 deg. in the heaters. There is a filtration plant for drinking water.

Fire protection is afforded by a large centrifugal pump, capable of delivering 500 gal. per minute against a pressure of 130 lb. This is driven at 1800 r.p.m. by a 75 hp. wound-rotor induction motor, having a drum-type controller.

Electrical Equipment

As already stated, the current is generated at 240 volts, 60 cycles, two-phase, and is conducted by four-wire circuits to the generator busbars, from which two 3-wire circuits lead to the power and the heating busbars, respectively. From the former, two-phase, three-wire circuits lead to the various motors and from the latter single-phase, two-wire circuits lead to the laundry, and to the wards for incinerators and for food warmers.

A four-wire circuit from the generator busbars leads to the primaries of four single-phase 1 to 1 transformers. The secondaries connect with 2 two-phase, three-wire circuits supplying the lighting feeders. The circuits in the various buildings are taken off single-phase, two-wire. The object of the transformers is to effect a balance of the lighting load between the phases. Just why the less expensive balancing transformers were not selected for this service has not been satisfactorily explained. Reference to Fig. 8 will make plain the electrical connections.

Three motor-generator sets supply current at 110 volts for the X-ray apparatus and food conveyors and at 40 volts for charging the storage batteries of the tunnel cars.

Switchboard

The switchboard consists of ten panels—four generator, one exciter, one lighting, one power and heating, and three for feeders and circuits. The leads from the three 200-kv.-a. generators are each 600,000 circular mils

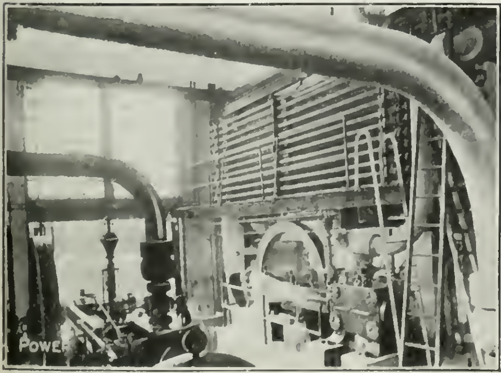

Fig. 9. Compressors and Condenser

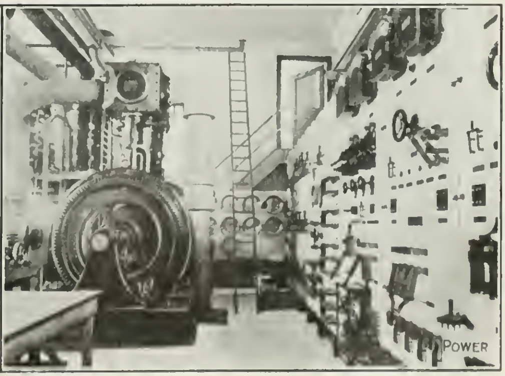

Fig. 10. Switchboard and One of the Units

PRINCIPAL EQUIPMENT OF SEAVIEW HOSPITAL PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	B & W, water-tube	316 hp.	Main steam supply	Hand fired; steam pressure 125 lb.	Babcock & Wilcox Co.
5	Blowers	Turbine		Furnace draft		L. J. Wing Mfg. Co
1	Coal conveyor	Bucket		Receiving hopper to bunker	Motor operated	Conveying Machinery Co.
1	Motor	Induction	10 hp	Driving coal conveyor.		
1	Coal weigher	Automatic		Weighing coal to each boiler		Avery Scale Co.
3	Pumps	Duplex, plunger	7½x4½x10-in	Boiler feed.		Henry R. Worthington
2	Injectors	"Metropolitan"		Boiler feed.		Hayden & Derby Mfg Co.
1	Heater	"Stillwell" open		Heating feed water	Capable of heating 45,000 lb. of water per hour from 70 to 210 deg	Platt Iron Wks.
2	Pumps	Direct-acting.	10x16x16-in	Vacuum on heating lines		Henry R. Worthington
2	Pumps.	Piston	7½x4½x10-in.	Returns from heating system		Henry R. Worthington
1	Pump	Plunger	7½x4½x10-in.	Drips from dry tank		Henry R. Worthington
1	Water meter	Venturi		Boiler feed line		Builders Iron Foundry
3	Engines	Angle-compound	18 and 28x14-in	Driving main generators	125 lb. steam, 257 r.p.m., noncondensing	American Engine Co.
1	Engine	Angle-compound.	12 and 19x10-in	Driving main generator	125 lb. steam, 300 r.p.m., noncondensing	American Engine Co.
2	Engines	Simple	8x8½-in.	Driving exciters	125 lb. steam, 300 r.p.m., noncondensing	American Engine Co.
3	Generators	Alternating current	200 kv.a	Light, heat and power	Two-phase, four-wire, 60-cycle, 240-volt	Fort Wayne Electric Wks.
1	Generator	Alternating current	75 kv.a	Light, heat and power.	Two-phase, four-wire, 60-cycle, 240-volt	Fort Wayne Electric Wks.
2	Exciters	Direct current	22 kw	Excitation for main units	125-volt	Fort Wayne Electric Wks.
1	Switchboard	Marble	10 panels		Lighting: single-phase, three-wire, 120-240 volts Heating: single-phase, two-wire, 240-volt Power: two-phase, four-wire, 240-volt	One half: Fort Wayne Electric Wks. One half: Metropolitan Elec. Mfg. Co.
1	Transformers	1 to 1 ratio	75 kv.a	To balance lighting load.	220 and 110 volts	Fort Wayne Electric Wks.
2	Tanks.	Horizontal.	7 ft. diameter	House service, cold water		
2	Pumps	Centrifugal	3 in	Supply house service tanks	50 to 60 lb. pressure	Henry R. Worthington
2	Motors.	Wound-rotor, induction	25 hp.	Driving house service pumps	1800 r.p.m., automatic float control	General Electric Co.
2	Starters.	Automatic		For motors on house service pumps		Cutler-Hammer Mfg Co.
1	Compressor	Locomotive type.	9½x9½x10-in	House service tanks	50 to 60 lb. air pressure, hand control	Westinghouse Air Brake Co.
1	Tank		4 ft diameter	Air supply to service tanks.		
2	Heaters	Cylindrical		House service, hot water	Water at 140 deg.	
2	Pumps	Centrifugal		Hot water supply.		Henry R. Worthington
2	Motors	Induction	3 hp	Driving hot water pumps		General Electric Co.
1	Pump	Centrifugal	500 gal. per min.	Fire service	1800 r.p.m., 130 lb. pressure	Henry R. Worthington
1	Motor	Wound-rotor induction	75 hp.	Driving fire pump	Drum type controller	General Electric Co.
1	Filters	Mechanical		Drinking water		Roberts Filter Mfg. Co.
2	Compressors	CO_2		Refrigeration system	50 atmospheres discharge pressure	Kroeschell Bros. Ice Mach. Co.
2	Condensers	Double pipe		Refrigeration system		Kroeschell Bros. Ice Mach. Co.
2	Engines.	Simple, Corliss	10x14-in	Driving compressors	125 lb. steam pressure	Murray Iron Wks.

and from the 75 kv.-a. machine, No. 0000. Between the generator busbars and each machine are a four-pole switch, a circuit-breaker and fuses, 450- and 250- amp. fuses being used for the larger units and 200-amp. for the smaller one. In specifying the switches, a current density of 800 amp. per sq.in. in solid parts, 100 amp. in stationary contact surfaces and 50 amp. for movable contact surfaces were provided.

REFRIGERATION SYSTEM

As a safety precaution, a carbonic anhydride (CO_2) system of refrigeration was selected, since any leak in an ammonia system around a hospital might prove dangerous. With a rated capacity of 60 tons of refrigeration for the 24 hours, this system serves the butcher shop, vegetable coolers, milk rooms, ward refrigerators and a can-ice plant, besides a cooling-water tank from which cold water is circulated throughout the hospital. These services are in multiple, with provision for regulating the temperatures independently.

There are two complete units, each consisting of a double-acting, horizontal compressor driven directly by a simple Corliss engine, and a double-pipe condenser operating on the countercurrent principle. The CO_2 is compressed to 50 atmospheres (750 lb.), and after passing through the condenser, goes to the brine tank, from which the brine is circulated by motor-driven centrifugal pumps.

The general contractor for the hospital was Luke A. Burke & Sons, of New York, with L. K. Comstock & Co. as sub-contractor for the electrical work, this part of the construction being supervised by the Department of Water Supply, Gas and Electricity. William J. Baldwin was consulting engineer on the mechanical equipment for the general contractor during the latter part of the construction, and the architect was Raymond Almirall.

⁂

Errata—In the table of principal equipment of the Kentucky Traction & Terminal Co.'s plant, published in the Oct. 13 issue, the 60- and the two 160-hp. turbines driving the circulating-water pumps were credited to the Kerr Turbine Co. They were built by the Terry Steam Turbine Co.

Management in the Boiler Room

By D. F. Cuynne

Careful attention is required in the management and operation of the power-plant boiler room equipped with modern apparatus, such as mechanical stokers, overhead bunkers and ash-handling machinery. As each part must be kept in the best condition, this can be done only by careful attention by the employee who has the handling of the various parts assigned to him.

Good results have been obtained in the plant with which the writer is connected. The plant is in operation twenty-four hours a day; the day load is much greater than the night load. A water tender is in charge of each watch of eight hours, each man being held responsible for the care and cleanliness of the entire fire room and also for one of the stoker engines and feed pumps. He must not only operate this equipment, but keep it clean. No excuse will be taken for leaving the plant untidy or the machinery dirty. In addition to a well kept fire room, the boilers are carefully fired.

It must not be overlooked, however, that to expect the best results from the boiler-room force, the convenience and feelings of the men must be considered. In this plant, every article and tool must be kept in its place. A quadrant and lever are in front of each boiler for operating the damper, and this damper-operating gear gives the fireman no excuse for wide variations in steam pressure or for leaving the front of the boilers. Each man has a chair so that between intervals of firing or cleaning he can rest comfortably. He also has a dust-proof locker for his clothing.

That the men may know that their attention to duty is recognized, they are requested to make suggestions as to operation or need of improvements and they are always accorded a careful hearing. Whenever it is possible, the men are given a day off when they request it for business or recreation; as a consequence, they are seldom absent without permission.

The following instructions for plant operation are carefully carried out by the repair man and others concerned in the daily routine:

1. Test out weekly all boiler settings and brickwork with a candle.
2. Test all injectors each morning and permit them to run for a short time.
3. Keep the openings around the rear furnace cleaning doors closed with asbestos cement.
4. Examine daily all boiler drain and surface blowoff valves for leakage.
5. Examine furnace fires frequently. Grates must be kept properly covered with fuel.
6. Excess clinker must be cleaned out during the noon hour or the night watches.
7. All firing tools must be kept in racks made for them and not rested against the boiler fronts.
8. Remove the draft gages twice a week, clean them out and fill them with clear water.
9. Clinker breakers are to be given a turn by hand every 30 min.
10. Water in all boilers must be maintained at the same level.
11. Steam is to be maintained at constant pressure.
12. Coal siftings must be removed from sifting pits frequently.
13. The floor in the front and the rear of the boilers must be kept clean.
14. Operating stems on the feed valves to the boilers are to be oiled each watch; the operating and track wheels on the coal tanks are to be kept well lubricated; all parts of the coal- and ash-handling apparatus are to be examined every day and kept properly lubricated and cleaned.
15. Back connections of the banked boilers are to be cleaned of accumulated clinkers and ashes during the night watches.
16. When the boilers are shut down for cleaning and repairs, all the valves are to be examined; new brickwork done, if required; clinker breakers examined and repaired, grate bars renewed, if required; all leaking tube caps made tight; baffle bricks renewed where necessary; all tubes in lower row to be thoroughly scraped and cleaned; all soot to be cleaned from tops of tubes; steam drum to be thoroughly scraped and cleaned and superheater to be examined and thoroughly cleaned.
17. Soot is to be cleaned from boilers in service daily
18. Each stoker engine and boiler feed pump is to be inspected daily and examined weekly

Universal Hose Tool

For some time J. S. McChesney & Co., of Chicago, have been supplying galvanized steel wire hose bands of various lengths for different sizes of hose. These bands secure the hose to the nipple over which it fits and in the power plant may be used on steam, compressed air or vacuum lines employing a rubber hose. The bands are electrically welded and, when properly tightened by a tool recently designed for the purpose, have withstood on test a direct pull on the hose of 600 lb.

This tool consists of a rod threaded over half its length with a slot in the unthreaded end to receive one end of the band. The other band end is slipped over one of three lugs projecting from a brass sleeve which may be moved lengthwise of the rod by means of a handwheel to which it is attached. The method of adjusting and tightening the band is shown in the accompanying illustrations.

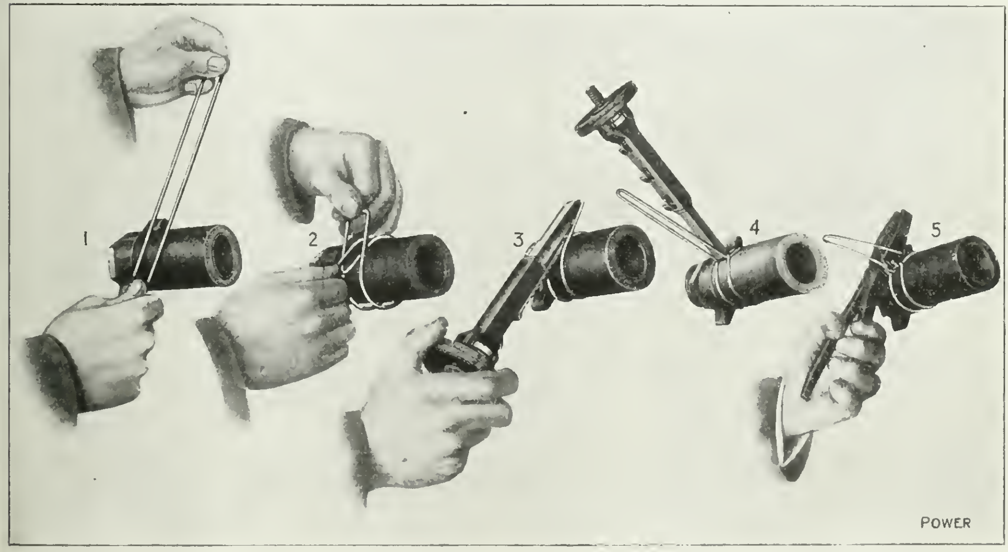

Fig. 1. Placing the Band. Fig. 2. Making the Loop. Fig. 3. Tool in Position. Fig. 4. Making the Band Tight. Fig. 5. Clipping the Ends of the Loop

First the small end of the band is placed on the hose, as in Fig. 1; then the large end is looped over the smaller, Fig. 2, and the tool is placed within the loops, Fig. 3. To tighten the band, the handwheel is turned to the right, and when the proper tension has been secured, the tool is swung up, as in Fig. 4, and removed. The final operation, Fig. 5, is to clip off and turn over the ends.

⁂

Impulse Wheel for 5412-Ft. Head—Among the exhibits of the firm of Piccard, Pictet & Co., Geneva, Switzerland, at the Swiss National Exposition being held at Berne, Switzerland, is an impulse wheel built for the Fully high head plant of the Société d'Electrochimie, a French company. This is a horizontal shaft wheel which will develop 3000 hp. at 500 r.p.m. Its wheel diameter is 11½ ft. and the jet diameter is 1½ in. The Fully plant will have the highest head water power in the world by a considerable margin. No machine for such severe conditions has been built prior to this one.

Locating Faults in Direct-Current Armatures—I

By F. A. Annett

SYNOPSIS—Open circuits in lap- and wave-wound armatures; their detection and means of overcoming the trouble.

⁂

The armature of the direct-current machine is a vital part and probably 90 per cent. of the operating troubles may be traced to this source. Armature faults may be divided into four classifications, namely: Open circuits, short-circuits, grounds and cross-connected coils. The first three may develop at any time, while the last is directly the fault of the workman who made the connections between the coils and the commutator.

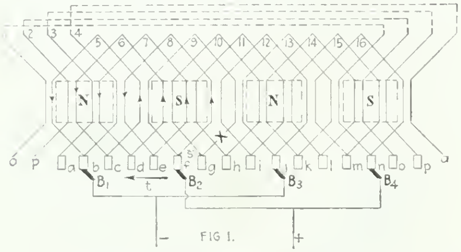

FIG 1.

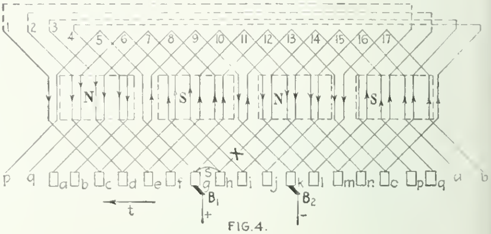

FIG. 4.

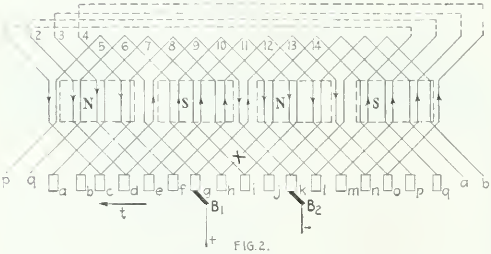

FIG. 2.

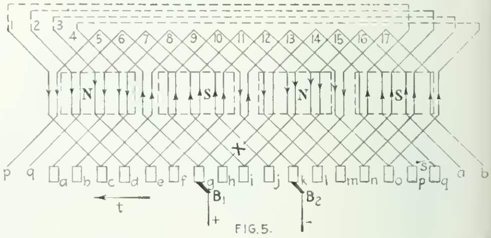

FIG. 5.

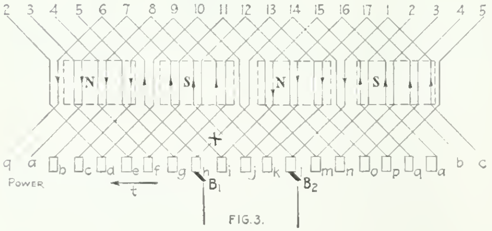

FIG. 3.

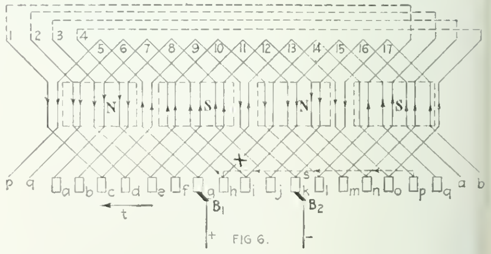

FIG 6.

Armature Windings Showing Open Circuits and Current Directions

An open-circuit in the armature winding may occur either in the body of the winding or more often where the coil leads connect to the commutator, the coil leads breaking off up close to the commutator bars. An open coil in the armature will cause severe sparking at the brushes, and the cause of the trouble is usually apparent from the nature of the spark, which is very long and heavy, sometimes, almost reaching from one brush to the other. It soon eats away the mica between the two commutator segments corresponding to the faulty coil and thus gives an indication as to its location. The number of burnt spots on the commutator caused by an open coil in the armature depends upon the way the winding is connected. If parallel wound (sometimes called lap wound) there will be only one burnt spot on the commutator for any open coil in the armature winding. This will occur between the terminals of the open coil, which will be made clear by referring to Fig. 1, showing a four-pole parallel-connected armature winding.

The winding is supposed to be cut through one side and laid out flat on the paper and an open circuit is shown at X in coil 9. By tracing out the current from brush B_2, it will be seen that current can flow from commutator segment f to segment e and on around through the winding to brush B_1, as indicated by the arrow-heads, but cannot flow from f to g; therefore, no current is flowing from brush B_2 to brush B_3. If the armature moves in the direction indicated by the arrow t, when brush B_2 rests on segment g, current cannot flow from B_2 to B_1 as before, but can flow from B_2 to B_3. This opening of the circuit between B_2 and B_1 and closing between B_2 and B_3, causes a severe spark between segments f and g, which are the segments that the terminal of the open coil are connected to; this, as before stated, gives a clear indication as to the location of the faulty coil.

If the open circuit cannot be located outside of the coil the trouble may be remedied by connecting segments f and g. One way of doing this would be to cut a little of the mica away from between the outside corners of segments f and g with a hacksaw and then expand them until they come in contact with one another across the insulation. A better way is to solder a jumper between the two segments as shown by the dotted line; this conection bridges the break in the armature circuit, and instead of the current flowing from f to g through coil 9, it flows directly through the jumper s.

In an armature which is series, or wave wound, there will be a burnt spot on the commutator for every pair of poles, that is, if the machine has four poles there will be two burnt spots, if six poles, three burnt spots, etc.

In Fig. 2 is shown diagramaticaly a four-pole series-connected armature winding. By tracing out the circuits it will be seen that the winding progresses around the armature in a series of waves. Instead of the coil terminals connecting to adjacent commutator bars, as in Fig. 1, they are connected to bars located approximately two pole spaces apart, or in this case approximately one-half the circumference of the commutator. In the six-pole machine, the coil terminals would be connected to segments located about one-third of the commutator circumference apart, etc.

Coil 14 is shown open at X and by following out the circuit from brush B_1, it will be found that current can flow around to brush B_2 in the path indicated by the arrow-heads, but cannot flow through the path where the conductors are left blank.

If the armature moves in the direction indicated by the arrow t until brushes B_1 and B_2 rest on segments h and l, as in Fig. 3, current will flow in the path indicated by the arrow-heads. In Fig. 3, it will be seen that current is flowing in the conductors that were dead in Fig. 2, and the conductors that were carrying current in Fig. 2 are dead in Fig. 3. This changing of the current from one path to another causes a severe spark between segments g and h, as described in Fig. 1. However, in Figs. 2 and 3, when segments p and q pass the brushes, a spark will occur between them for this is the other end of the open coil. Connecting the two segments together at either end of the burnt spots will close the open circuit, as in Figs. 4 and 5. Fig. 4 shows the break closed by connecting a jumper s between segments g and h, and in Fig. 5 it is closed by connecting a jumper between segments p and q.

In either case this has closed the open circuit but has also cut out a good coil, along with the open one, as it will be seen by tracing out the current that coil 6 is cut out of circuit along with coil 14, which is the faulty one. A better method of repairing the fault would be to connect a jumper across the back of the commutator from segment h to segment p, as at s, Fig. 6. This connects the ends of the faulty coil, which is the only one cut out of circuit, as indicated by the arrow-heads.

⁂

Will Quizz, Jr.

SYNOPSIS—Will Quizz wants to know how to determine how much water should be evaporated by coal of a given quality or B.t.u. value.

⁂

"The other day, Chief, you told me that each B.t.u. was equal to 778 foot-pounds of work or mechanical energy."

"Yes, that is the mechanical equivalent of heat."

"Well, since then I have been looking up the table of values of various coals and find that they run as high as 15,000 B.t.u. per pound."

"Yes, good coal has that value."

"Then, each pound of 14,000-B.t.u. coal burned per hour should produce

$778 \times 14,000 = 10,892,000$ *foot-pounds of energy*

which would be equal to 5.5 hp. per pound of coal per hour."

"Right you are, Will; if there were no losses in the process it would be possible to get 5½ hp. for one hour from each pound of such coal. What do we get? Is it anywhere near that figure?

"I am ashamed to say, if those figures are right. I guess it is nearer the reverse, 5½ lb. per horsepower-hour instead of 5½ hp.-hr. per pound."

"The full heat value of fuel cannot be realized in practice, but in order to have a basis of comparison, it is necessary to know the thermal limitations, and strive to attain as near the maximum as possible. After finding the calorific value of the coal, the next step in the process is to find the theoretical evaporation of water per pound of that coal. The total heat of steam, as shown in the steam tables, as referred to in our previous chat, makes it possible to predict the limit of the evaporative capacity of any fuel when its calorific power is known. Thus the pounds of water evaporated per pound of fuel burned will be the quotient found by dividing the total heat (above the feed water) in the steam, at a given temperature and pressure, into the calorific power (B.t.u.) per pound of the fuel. For example, coal of 11,070 B.t.u. would evaporate at atmospheric pressure, or from and at 212 deg., nearly 11½ pounds of water.

$$\frac{B.t.u.}{total\ heat} = \frac{11,070}{970.1} = 11.5\ lb.\ of\ water$$

"At higher pressure, or with feed water below 212 deg. (either or both), the value of the divisor (970.1) would increase, and with the dividend or the B.t.u. in the coal remaining the same, the quotient representing the pounds of water evaporated would grow less. As an example of the above, suppose that feed water of only 106 deg. is to be made into steam at 100 lb. gage, the total heat would be 1083, to be divided into the 11,070 B.t.u., which would gave only 13 lb. evaporation per pound of the same coal. Of course, this figure is never reached in boiler practice.

"The losses in the boiler room are:

"1. Raising the air from the temperature of the room to that of the gas in the flue.

"2. Evaporating and superheating any water in the fuel and the air.

"3. Heating earthy matter or ash in the coal.

"4. Heating the fresh fuel and gases to a point at which they will burn.

"5. Radiation from boiler setting, etc.

All of the foregoing are practically unavoidable. Others which are more or less preventable are:

"6. Unburned fuel dropping into the ashpit.

"7. Unnecessarily high temperature in the stack.

"8. Incomplete combustion allowing unconsumed carbon and smoke to escape from the stack.

"9. Excess air introduced either below the grate or above it or beyond the bridge wall.

"10. Discharging solid carbon in the form of sparks or cinder from the stack. These, together, may amount to 25 to 35 per cent.

"So you see, Will, it requires eternal vigilance to get anywhere near the possible thermal efficiency of the fuel into the steam. Then there are losses all along the line after that. But the despised boiler is a more efficient piece of apparatus than the engine, notwithstanding the difference in their polish."

* *

Lubrication and Lubricants

By Ray Francis Yates

SYNOPSIS—Tells what characteristics oils should have for different services and how to test them for these by simple methods.

*

Friction may be defined as the resistance offered to the motion of one body sliding or rolling over another.

Friction and Lubrication

To make the relation between lubrication and friction easily understandable, consider Fig. 1. The body *A* is at rest upon the inclined plane *B*. The angle of the plane is increased so that the friction between the body and the plane will just prevent the body from sliding down. The static friction (friction of rest) between the body and the plane will be dependent upon three factors—i.e., the conditions of the surfaces, the degree of the angle of the plane and the weight or pressure of *A*. If the angle is increased to a point where the body gains motion, it will be found that the kinetic friction (friction of motion) is much less than the friction of rest. With the introduction of a lubricant between the body and the plane, the angle may be decreased and yet the body will gain motion. After the introduction of the lubricant the friction will no longer take place between the body and the plane but between the surfaces of the plane and the lubricant and the body and the lubricant. Molecular or internal friction also exists in the oil and increases with the viscosity of the lubricant, if an ultra-viscid oil was introduced between *A* and *B* it would tend to retard motion rather than to assist it. The coefficient of friction is the ratio of the force of friction to the normal pressure. The coefficient of friction for dry or poorly lubricated surfaces is independent of the area of contact and the velocity.*

In a well lubricated bearing the amount of friction is not constant: it varies with the velocity and the temperature. The friction tends to decrease until a temperature of 75 deg. F. or over is reached, and in most oils after it is reached, the friction increases quite rapidly. This is due to the oil losing its viscosity through excessive heat, thus causing it to become so thin that it is squeezed out of the bearing and the conditions of a dry bearing are approached. The temperature at which different oils are affected depends upon the properties of the oils.

In the lubrication of machinery, the lighter the shaft and the greater the speed, the less viscid will be the oil required to lubricate it. If an extremely heavy or viscid oil were introduced between the bearings of a small spindle traveling thousands of revolutions per minute, the cohesive force relative to the molecular construction of the oil would be far too great and could not be overcome without an increased amount of friction between the surfaces of the bearings and the lubricant. But, if a thin oil were used to lubricate large bearings carrying great pressure and operating at low speed, the reverse conditions would result. The oil would not possess sufficient viscosity to remain between the surfaces but would be squeezed out and a hot bearing result. When the pressure is small and the speed great, a lubricant of low viscosity is to be desired. When the pressure is great and the speed low, one of great viscosity is to be sought. In most cases, it will be found that high pressures are intimately connected with slow motion and light pressures with greater motion.

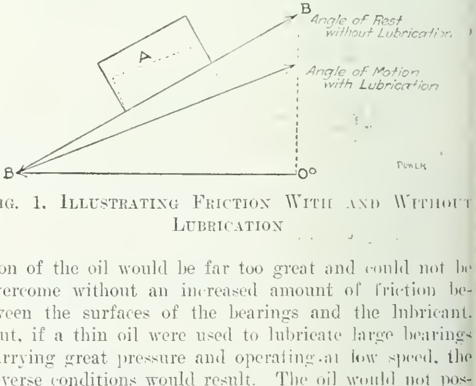
B
Angle of Rest without Lubrication
A
Angle of Motion with Lubrication
B
O°
POWER

Fig. 1. Illustrating Friction With and Without Lubrication

Too much stress cannot be laid upon the importance of selecting a lubricant for a specific purpose—one that will in every way meet the conditions under which it is to operate. An oil prepared to withstand the high temperatures of gas-engine lubrication could not be successfully employed for another purpose. If a manufacturer prepares an oil for low-temperature use it could not meet the requirements of gas-engine lubrication, for that oil possesses certain properties which it can retain only when operating under the conditions for which it was intended. An oil for low temperatures is worthless for high temperatures, for the oil would immediately lose its viscosity and carbonize. When an oil carbonizes, the hydrogen passes off in its natural state—a gas, leaving the carbon a solid, impure mass.

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*When speaking of the coefficient of friction being independent of velocity, it is used only when referring to kinetic friction, as static friction is greater.

SELECTION OF LUBRICANTS

In the selection of lubricants, the conditions under which they are to be used should first be approximated—i.e., pressure, speed and, in some cases, temperature. It is the practice in many places to use the same oil on small, high-speed machines as on the hangers of the line-shaft. The universal use of one oil in any plant is due to ignorance rather than economy.

ANIMAL AND VEGETABLE OILS

The compositions of animal and vegetable oils are extremely complex, being mixtures of organic salts of organic acids, alcohols and hydrocarbons. They appear both as oils and fats, but their solidification is merely a physical property and entirely dependent upon temperature. These oils are referred to by many chemists as "glycerides" as they are capable of yielding glycerine by the process of saponification.

Vegetable oils are divided into two distinct classes, the volatile and the fatty oils. Their identification may be readily learned by a very simple method. Volatile oils will not leave a fixed stain upon paper; fatty oils will.

Vegetable and animal oils are little used today as lubricants, being almost entirely replaced by hydrocarbons. With the increase of manufacture by machinery and the dawn of motor traction, these oils soon become scarce and expensive.

MINERAL OILS

Hydrocarbons or mineral oils are, as their name implies, compounds of hydrogen and carbon, the general chemical expression being C_nH_{2n+2}. These two common elements unite in varying proportions to form many hydrocarbon compounds, each with its individual characteristics. The more heavy or viscid mixtures are used extensively as lubricants. The American petroleum-producing sections are Pennsylvania, Ohio, California and Ontario. Certain parts of Russia are also rich in petroleum. While hydrogen and carbon are the chief constituents of petroleum, nitrogen, oxygen and sulphur are also found; sulphur is a very objectionable ingredient. Ohio, California and Canadian petroleums contain some sulphur.

METHODS OF TESTING LUBRICANTS

In the following paragraphs are explained the more important tests and their simple execution.

Viscosity Test—Viscosity is the degree of fluidity, depending upon molecular or internal friction. It is relative to the internal properties, cohesion and adhesion. The greater the amount of cohesion between the particles of oil, the greater the pressure the oil will be able to withstand before its particles are broken. Adhesion is also an important function, and is the amount of affinity an oil shows in attaching itself to foreign bodies or surfaces. The closer an oil will adhere to the surface of a bearing, the better it will resist the pressure on it. It is essential that a good lubricating oil possess a fairly high degree of adhesion—that is, a good lubricant to a reasonable extent must be both adhesive and cohesive, the two properties being intimately connected with viscosity. It is generally conceded among oil dealers and users that an oil, to be a good lubricant, must have a high degree of viscosity. This is erroneous. The viscosity should be in proportion to the weight or pressure under which it is to be used; great viscosity for heavy pressures, and *vice versa*. Some oils break down in places when forming a film between bearings. The increased friction which will result from this raises the temperature objectionably and lowers the viscosity. With one condition assisting the other the bearing will soon give trouble.

Oil viscosity is determined by two different principles. One depends upon the time required for a given quantity to pass through an orifice of standard dimensions; the other is based upon the resistance to motion offered a rotating disk by the oil. Because of the simplicity and accuracy of the former method it is universally used.

A common and simple method of testing the relative viscosity of different oils without any especially designed apparatus is to fill a glass pipette with the oil to be tested and record the time it requires to run out. This method is accurate enough in comparing oils, and can be enhanced by keeping the oil temperature uniform.

Flash Tests—The flash point is important, especially if the lubricant is to be used under high temperatures. The usual way to test for flash point is to heat a small quantity of oil in an evaporating dish over a bunsen burner. The temperature should not rise over 8 deg. F. per minute, as accurate results cannot be obtained. After the temperature has reached about 150 deg. F., a small flame should be brought near the surface of the oil and applied at every one or two degrees rise. Presently, a snappy, blue flame will shoot across the surface of the oil. The temperature should be recorded at the appearance of the flame as that is the flash point. A flash point of 350 deg. F. is sufficiently high for oils for ordinary lubrication; lubricants for gas engines should have a flash point of over 500 deg.

Burning Point—If heating the oil is continued and the flame applied at regular intervals, the blue flame will appear more frequently and increase both in frequency and volume in ratio to the rise in temperature. When the temperature reaches a certain degree the flame fails to automatically extinguish itself and remains on the surface. This should again be carefully noted; it is the burning point.

Another method of obtaining the burning and flashing point of oils is the "closed flash test," and is carried out in an inclosed compartment heated in the usual manner. The results differ fifteen or twenty degrees.

Evaporation Test—A small quantity of the oil is carefully weighed, placed in a small, open dish and subjected to a temperature of 212 deg. F. in a closed compartment for 21 hours. For accurate results the temperature should be kept as uniform as possible. The oil is then reweighed and the amount evaporated learned by subtracting its original weight with the latter result. Between 0.25 and 0.5 per cent. is a common amount for an oil to decrease. Any oil losing more than 3 per cent. should be regarded with suspicion. When cylinder oils are being tested it is customary to increase the temperature to 350 deg., weighing every hour and noting the rate of evaporation. A cylinder oil losing 2 per cent. in 50 or 60 hours is quite safe.

Specific-Gravity Test—The two most common methods of learning the specific gravity of an oil are by means of the hydrometer and the specific-gravity bottle, the latter being by far the more accurate.

A small, thin glass bottle will serve the purpose admirably. The exact weight of the bottle should first be recorded; then it is filled with the oil and again carefully weighed. The weight of the bottle is then deducted from that of the bottle and the oil combined, the result being the weight of the oil. Then the bottle is emptied, all traces of the oil being removed and the bottle filled with the same amount of water. (This may be done by properly marking the bottle or filling it until it overflows.) The bottle is then weighed and its weight again deducted, giving that of the water. The weight of the oil is then divided by that of the water, the result being the specific gravity. Thus:

	Grams
Weight of bottle and oil	41.535
Weight of bottle	10.363
Weight of oil	31.172
Weight of bottle and water	44.235
Weight of bottle	10.363
Weight of water	33.872

$$\frac{\text{Weight of oil } 31.172}{\text{Weight of water } 33.872} \quad 0.9203 \text{ specific gravity of the oil.}$$

This is an important test in identifying oils.

Acid Test—Acids in oils are common and most undesirable. Many oils find their way upon the market polluted with sulphuric acid, resulting from improper washing at the refinery. Oil containing an appreciable amount of this acid should be regarded with extreme caution, for the acid is a severe corrosive agent.

Acid may be readily detected by thoroughly mixing a small quantity of oil with an equal amount of pure, warm water. The mixture should then be tested with neutral litmus paper. If acid is present the paper will immediately turn red; its sensitivity may be greatly increased by introducing it into the fumes from nitric or hydrochloric acid till it becomes partly red. After it is dried and part of its surface is immersed in the oil to be tested the very smallest amount of acid will turn the part immersed just a shade darker than the rest.

Friction-Testing Machines—It is customary with many large manufacturers and railroads to severely test oils under the conditions under which they are to be used before purchasing them. This is accomplished in an oil-testing machine—i.e., a machine in which the operating conditions are made so flexible that the speed and pressure of the bearing it is proposed to be used on may be attained. If its behavior is carefully noted while being tested, its possibilities while working under the specified conditions may be accurately ascertained.

The Thurston oil-testing machine is a standard type in America, being used by the United States Navy as well as by many railroads. This machine is pictured in Fig. 2. Analyzing it mechanically, it consists of a shaft revolving between the bearings B, B_1 and B_2. The pressure on the bearing B can be regulated by adjusting the coiled spring C. The amount of pressure exerted upon B is indicated by the dial D. A thermometer is attached to register the exact temperature of the bearing. The machine is rotated by the cone of pulleys E. Oil is introduced into the bearing B and when the shaft is brought into motion it causes a displacement of the pendulum K along the graduated arc FF. The displacement of the pendulum will be in ratio to the amount of friction offered by the oil in the bearing. The less the deflection of the pointer on the scale, the greater the lubricating value of the oil. The arc is so graduated that, by dividing the reading on the dial by the pressure shown on the index D, the coefficient of friction is given. This is an accurate method and avoids mathematical complications.

Graphite

For many years the value of graphite as a lubricant has been recognized and its commercial application has received impetus on the appearance of the fine artificial product produced at the very high temperature of 7500 deg. F. It was while carrying on experiments in an electric furnace with his product carborundum that Dr. Acheson noticed that when the substance was carried to a temperature far beyond that of its production, decomposition occurred and the silicon portion of the carborundum would dissipate as volatile matter, the carbon portion remaining as pure graphite.

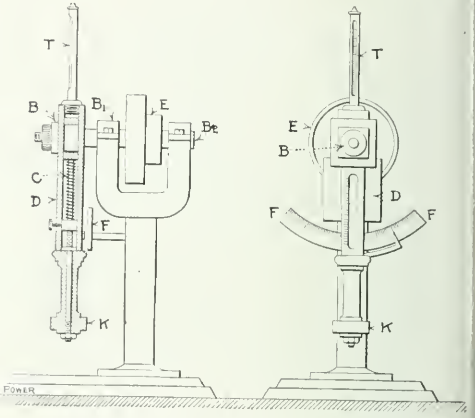

Fig. 2. Thurston's Friction Machine

Today, graphite is being disintegrated to such an extreme degree of fineness that it requires 339,000 of its particles to extend one inch. In this condition of subdivision it will remain suspended in solutions; also these particles pass unimpeded through filter paper.

Colloidal Graphite as a Lubricant

Oil containing colloidal graphite constitutes a most dependable source of lubrication. When introduced into a bearing the graphite particles, being infinitesimal, penetrate the pores of the metal. These particles accumulate until the surfaces in contact are completely amalgamated with a thin graphite veneer which has been termed a graphoid surface. This film, unlike that of oil, is free from intrinsic friction and exceedingly stable in its construction, being capable of withstanding far greater pressures than any form of hydrocarbon regardless of its viscosity. The graphoid surface not only greatly reduces friction but practically eliminates wear. So lubric is the nature of this graphite film that upon its establishment oil consumption may be considerably reduced. If the oil supply of a bearing is either accidentally discontinued or completely consumed, the graphoid surface alone will hold up as a lubricant for a long time, preventing a hot bearing.

It has been found, after many exhaustive tests, that 0.35 per cent. of colloidal graphite properly diffused in oil is sufficient.

Colloidal graphite in gas-engine lubrication possesses many advantages over plain oil. The formation of carbon deposits on cylinder walls is due to the inability of the piston to effect a thorough wiping back of the lubricating oil and a portion remains in the cylinder and is decomposed. This source of trouble usually ceases with the use of colloidal graphite. The minute particles immediately enter the interstices of the metal and form a soft, unctuous film that is unattainable by any mechanical operation. Of course, with the establishment of this film there must be an almost perfect fit between the piston and the cylinder walls, effecting a more thorough retreat of the oil. The temperature of a gas engine in operation, although very high, produces no effect upon graphite either physically or chemically as it is refractory capable of withstanding 7600° F. before any signs of vaporization are shown.

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Automatic Cutoff Recorder

By F. W. Salmon

Much can be done in the power plant toward ascertaining what the power is costing and by gathering useful data later by employing such instruments and appliances as can be purchased or improvised at little expense.

Fig. 1 shows a cutoff and power recorder that can be easily arranged for use with a Corliss engine. The pencil *A* is secured to the governor dashpot rod by clamping a piece of sheet tin to the rod with two bolts. The tin has sufficient spring, if suitably proportioned and adjusted, to keep the pencil against the paper without producing too much friction. A one-way cock is secured to the wooden block *B*, clamped to the governor column by a U-bolt. The indicator is coupled to the one-way cock in the usual way. The regular piston and pencil motion of the indicator is not used.

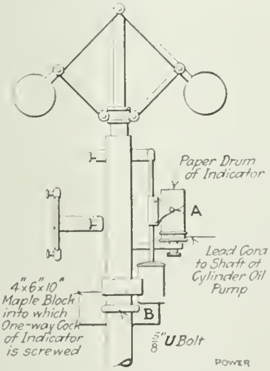
Paper Drum of Indicator
A
Lead Cord to Shaft of Cylinder Oil Pump
4"x6"x10" Maple Block into which One-way Cock of Indicator is screwed
B
5/8" U Bolt
POWER

Fig. 1. Arrangement of Indicator

Almost any device that will wind the drum (or release it) about three-fourths of a revolution in about twelve hours at a uniform rate, will answer for moving the paper drum. In some cases the paper-drum cord may be wound on the cylindrical oil-pump shaft; a float in a pail or can of water from which the water is allowed to slowly drain is convenient. Then, again, one end of the cord may be wound around the hour-hand spindle of a cheap clock clamped to the engine frame or other convenient part.

The indicator drum is revolved by its own spring, the speed being controlled by the clock. The engineer makes a small mark with a pencil against the pencil on the governor dashpot rod at various periods, say at each hour, for convenience in reading the chart afterward. Before starting or after stopping, a base line should be drawn in the usual manner as with the ordinary indicator diagram.

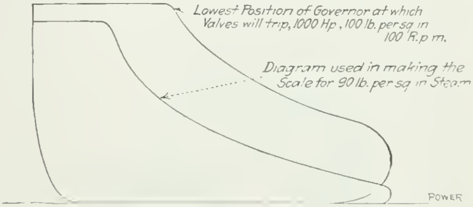
Lowest Position of Governor at which Valves will trip, 1000 Hp., 100 lb. per sq. in 100 R.p.m.
Diagram used in making the Scale for 90 lb. per sq. in Steam
POWER

Fig. 2. Diagram for Reading Scale

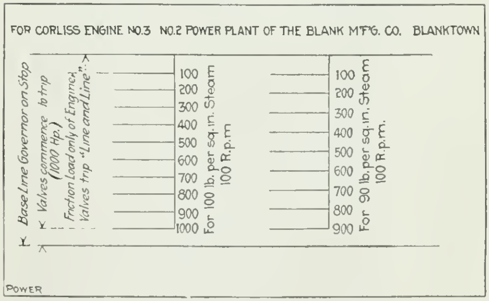
FOR CORLISS ENGINE NO.3 NO.2 POWER PLANT OF THE BLANK M'F'G. CO. BLANKTOWN
Base Line Governor on Stop
Valves commence to trip (1000 Hp.)
Friction Load only of Engine
Valves trip "Line and Line"
100
200
300
400
500
600
700
800
900
1000
For 100 lb. per sq. in. Steam 100 R.p.m
100
200
300
400
500
600
700
800
900
For 90 lb. per sq. in. Steam 100 R.p.m.
POWER

Fig. 3. Celluloid Horsepower Scale

The scale for the chart is easily obtained by taking indicator diagrams from both ends of the cylinders at the times or points noted on the chart, then calculating the indicated horsepower. By taking diagrams and finding the power at several heights of the governor in this way, a curve can be easily drawn (Fig. 2), and the power indicated and recorded automatically by the governor scaled off quickly at any time. Celluloid is good material on which to draw the chart scales, Fig. 3, as it can then be placed over the diagram and a reading taken.

It is not intended to use such a power recorder continuously throughout the year, but for a week at a time several times a year, or when for some special reason it is desirable to obtain such a record.

Usually, if the steam pressure is kept fairly uniform, it will not be necessary to make corrections for the slight variations, but a number of scales may be drawn on the celluloid chart for several steam pressures if desired.

Oil-Engine Drive for Existing Ice-Making Plants

By Robert P. Kehoe

SYNOPSIS—An argument, supported by figures, for the oil engine as motive power for can-ice plants, especially in localities where coal is relatively high.

*

Since the successful installation of so many new ice-making plants of capacities ranging from 15 to 400 tons daily, with oil-engine drive, the question of applying this type of motive power to existing plants arises. There are steam-driven distilled-water can plants in operation which produce six or seven tons of ice per ton of coal burned under the boilers. There are also plants of the same type which produce only three or four tons of ice per ton of coal, but the majority probably average about five tons of ice for each ton of coal.

If coal can be purchased for $2 or $2.50 per ton, it is difficult to show much saving with oil-engine drive, but where coal costs $3 or $4 per ton, the saving is considerable. The price of oil must also be considered, as the relation between the cost of the two fuels will decide whether or not the change will be an advantage.

In some localities, such as California, coal costs $5 or $6 per ton, while oil can be bought for 75 cents per barrel. The saving here would be enormous, but as oil is also used under the boilers instead of coal, the comparison should be made between the relative amounts of oil used.

Assuming average conditions and taking the price of coal at $3.50 per ton, and oil at 3½ cents per gallon, the following table will serve as a basis in determining the amount of saving possible by installing oil-engine drive to take the place of steam power in existing distilled-water can plants. The figures also cover the cost of changing the plant to a raw-water system:

TABULATION SHOWING INITIAL COST AND SAVING OF APPLYING OIL-ENGINE DRIVE TO EXISTING DISTILLED-WATER CAN-ICE PLANTS

Ice-making capacity in tons per 24 hr.	15	25	50	100
Approximate horsepower of engine for machine and all auxiliaries	60	100	200	400
Approximate number of 300-lb. cans	210	350	700	1400
Daily approximate coal consumption in tons	3½	5	9½	18
Daily cost of coal at $3.50 per ton	$12.25	$17.50	$33.25	$63.00
Oil consumption daily of high economy oil engines, in gallons	80	120	225	430
Daily cost of oil at 3½c. per gal.	$2.80	$4.20	$7.88	$15.05
Saving in cost of fuel with oil engine drive	9.45	13.30	25.37	47.95
Total saving per year with 50% yearly load factor	$1701	$2,394	$4,567	$8,631
Approximate cost of installing aerating system	1200	1,800	3,300	6,000
Approximate cost of oil engine and accessories, including transmission	6500	8,500	15,000	28,000
Total cost of change	7700	10,300	18,300	34,000
Percentage of saving on investment	22	23	25	26

The horsepower of the engine is given approximately and is supposed to take care of the auxiliaries as well as the main unit. The auxiliaries can be arranged to be driven by belt. If motors are already in use, a generator can be installed with the engine to supply the current. If there are several old steam pumps and other steam-driven auxiliaries, it may pay to replace them altogether.

The coal consumption is based on less than 5 tons of ice per ton of coal for the 15-ton plant, and nearly 6 tons in the case of the 100-ton plant, with the consumption for the 25- and 50-ton plants graduating between the two. This should be a conservative basis and, if anything, favors the steam plant, as many plants fail to equal these figures.

The consumption of oil is based on the use of high-economy oil engines which will burn low-grade oils and operate continuously to fill the hard service demanded in ice-making plants. There are also oil engines somewhat less expensive, which will burn low-grade oils with poorer economy. While the fuel consumption may be higher, the saving in initial cost will be attractive in some cases, particularly where oil is very cheap and 25 to 50 per cent. more expense per day in the fuel item will be only a small amount.

One quality in the type and make of oil engine is absolutely essential and that is reliability. The continuous service required is possible only with a high-grade engine of heavy construction. Such designs have been developed in recent years, and the many thousand horsepower now in operation is sufficient to satisfy the most skeptical purchaser that this kind of motive power is perfectly reliable.

The price at 3½ cents per gallon is an average of the quotations in various sections of the United States. On the Atlantic seaboard Mexican crude oil is sold for about 3 cents per gallon on five-year contracts. Fuel oils are also sold in this section for about the same price. In the Middle States various fuel oils are sold for 3 or 4 cents per gallon. Texas, Louisiana and the vicinity provide cheap crude and fuel oils in the Southwest. Kansas and Wyoming oil fields are now supplying the local market at low prices. California furnishes crude oil at lower cost than any other state.

The figures given in the table for initial cost of installing the aërating system are approximate and cover air blower, core pump, air-distributing pipes and drop tubes, with something added for the work of installation and contingencies. The estimated cost for the oil engine or engines is supposed to cover all usual accessories such as water and exhaust piping, fuel-storage tank and foundation, also transmission.

Slight changes in the auxiliaries of the present plant may also be considered as part of the figures, although a careful estimate should be made for every plant to determine the cost of changing to oil-engine drive and if the investment will earn a sufficient return to justify the outlay.

Nothing is mentioned in the table about the saving of expense due to the elimination of the boiler plant. The labor required in the engine room will be the same as in a steam plant. The engineers should be good mechanics and possibly machinists, but no firemen will be needed. On the other hand, the labor necessary for properly operating the freezing system will be more. In the 25-ton plant two men day and night can handle the freezing and aërating system and also the ice storage. During the night it will be possible to get along with one good man, provided the tank is equipped with a double hoist.

Two men day and night should be sufficient for a 50-ton plant, which has double hoists, although another man may be required for the ice storage, particularly during the day. In a 75-ton plant it will be necessary to have three men, and in the 100-ton plant twice as many men as in the 50-ton installation.

On the whole, the labor may be somewhat less with the oil-engine drive and raw-water system, but nothing has been figured in the table for this possible saving.

The approximate earning power of the additional investment seems to be in the neighborhood of 25 per cent. in all the sizes of plants for which figures are given, and it may be safely assumed that plants of any other capacity, except very small ones, will be improved to the same extent.

No consideration has been given to possible changes in the building, which may be necessary in those installations where the engine room is already crowded. There will probably be sufficient room in the average plant, with little or no building alteration, but should an extra expenditure be required for this purpose, the amount can be included in the initial cost when estimating the exact results in each particular plant.

Another question which frequently arises is the supply and price of oil. Not long ago the cost of fuel oil suffered a considerable increase. This was occasioned by an excessive demand owing to the widespread use of this fuel under boilers, in furnaces, kilns and other similar work. Since then the Mexican oil fields have been opened and an unlimited supply is now assured from that country. In fact, it has been possible for several months past to make five-year contracts for the delivery of Mexican crude oil to plants on or near the Atlantic seaboard and the Gulf States.

California, Kansas and Wyoming have opened new fields and the production in Texas and Louisiana is ample to supply fuel in that section at low prices. Furthermore, Central America, South America and the Northwest offer undeveloped oil country for the future supply.

If the demand increases to an extraordinary extent, the price will increase. This will reduce the widespread use for boilers, kilns, etc., but it is unlikely that fuel or crude oil will become so high as to preclude the advantage and economy of oil engines.

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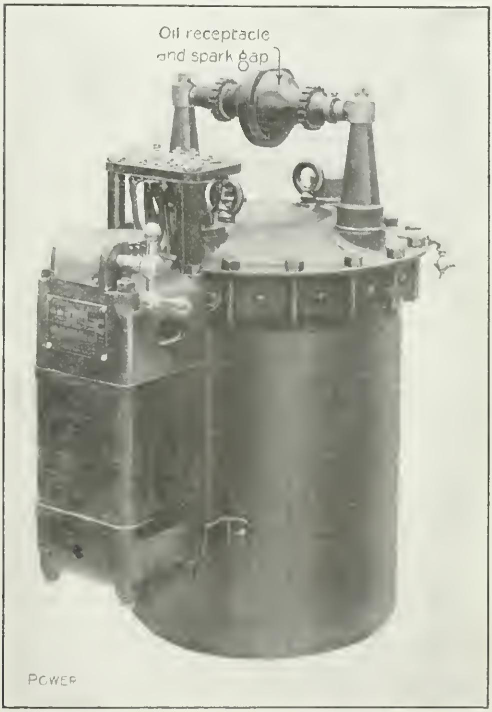
Oil-Testing Set

With high-voltage, oil-insulated apparatus, in order to nsure successful operation, it is necessary to maintain the dielectric strength of the oil at maximum value. For this purpose a testing set has recently been developed by the General Electric Co. for determining the dielectric strength of oil. The set consists of a testing transformer with an induction regulator for voltage control and an oil spark gap. All the parts are assembled and mounted o as to form one complete unit, which is compact and may be conveniently and quickly operated. The set is built for both 25 and 60 cycles.

The transformer has a rating of 3 kv.-a. at 30,000 volts, but may be operated at 10 per cent. above this. The high-voltage winding is equipped with a voltmeter coil for indicating directly the test voltage and the induction regulator allows a variation of voltage from zero to maximum. The regulator, as well as the transformer, is arranged for series-parallel connection, making the set suitable for use on 100- or 200-volt circuits. A dial is attached to the top of the rotor shaft of the regulator and is accurately graduated to give readings of the test voltage directly in kilovolts.

The oil is tested between flat metal disks, located inside the receptacle. One electrode is stationary, and the other has a micrometer adjustment with an adjustable zero index. This permits taking up readily any wear in the gap. The receptacle is designed so that it may be conveniently cleaned, and care has been taken that the quantity of oil required for tests is as small as is consistent with good results. It is estimated that three-quarters of a quart of oil is sufficient for one sample, allowing five tests on clean oil. The oil receptacle and spark gap are supported by the high-voltage terminals of the transformer and by merely turning the receptacle about its horizontal axis, the oil which has been tested, may be emptied.



Oil-Testing Set Complete

The receptacle and gap may also be easily removed from the supports, leaving the transformer free from high-potential testing of any kind up to 33,000 volts.

The weight of the 60-cycle set complete is 465 lb., height 30 in., length 24 in. and width 17½ in.; the weight of the 25-cycle set complete is 670 lb., height 32 in., length 26½ in. and width 20½ in.

Comparison of Standard Linear Units

Approximate Values in Common Fractions, Decimal Equivalents or Both

A	One Millim. Equals	One Centim. Equals	One Inch Equals	One Decim. Equals	One Foot Equals	One Yard Equals	One Meter Equals	One Rod Equals	One Chain Equals	One Hectom. Equals	One Furlong Equals	One Kilom. Equals	One Mile Equals	One Knot Equals	A
Millimeters	1	10	25.4	100	304.8	914.4	1000	5029.2	20116.8	100,000	201,168	1,000,000	1,609,344	1,853,256	Millimeters
Centimeters	1-10 0.1	1	2.54	10	30.48	91.44	100	502.9	2011.68	10,000	20,116.8	100,000	160,934	185,325	Centimeters
Inches......	1-25 0.03937	4-10 0.3937	1	3.937	12	36	39.37	198	792	3937	7920	39,370	63,360	72,963	...Inches
Decimeters	1-100 0.01	1-10 0.1	1-4 0.254	1	3.048	9.144	10	50.29	201.17	1000	2011.7	10,000	16,093	18,5[illegible]5	Decimeters
Feet........	1-300 0.00328	1-30 0.03281	1-12 0.08333	1-3 0.32808	1	3	3.2808	16.5	66	328.08	660	3280.8	5280	6080.2	Feet
Yards......	1-900 0.00109	1-100 0.01094	1-36 0.0278	1-9 0.10936	1-3 0.33333	1	1.0936	5.5	22	109.36	220	1093.6	1760	2026.7	....Yards
Meters	1-1000 0.001	1-100 0.01	1-40 0.0254	1-10 0.1	3-10 0.3048	9-10 0.9144	1	5.0292	20.116	100	201.17	1000	1609.3	1853.3	... Meters
Rods.......	1-5000 0.0002	1-500 0.00199	1-200 0.00505	1-50 0.01988	2-33 0.06061	2-11 0.18182	1-5 0.19884	1	4	19.884	40	198.84	320	368.5	Rods
Chains.....	1-20,000 0.00005	1-2000 0.0005	1-800 0.00126	1-200 0.00497	1-66 0.01515	1-22 0.04545	1-20 0.04971	1-4 0.25	1	4.971	10	49.71	80	92.12	. Chains
Hectometers	1-100,000 0.00001	1-10,000 0.0001	1-4000 0.000254	1-1000 0.001	3-1000 0.00305	1-110 0.00914	1-100 0.01	1-20 0.05029	1-5 0.20117	1	2.0117	10	16.093	18.53	Hectometers
Furlongs...	1-200,000	1-20,000 0.00005	1-7700 0.00013	1-2000 0.0005	1-660 0.00152	1-220 0.00455	1-200 0.00497	1-40 0.025	1-10 0.1	1-2 0.4971	1	4.971	8	9.212	Furlongs
Kilometers..	1-1,000,000	1-100,000 0.00001	1-40,000 0.000025	1-10,000 0.0001	3-10,000 0.00031	1-1100 0.00091	1-1000 0.001	1-200 0.00503	1-50 0.02012	1-10 0.1	1-5 0.20117	1	1.6093	1.853	..Kilometers
Miles.....			1-63,000		1-5280	1-1760 0.00057	1-1600 0.00062	1-320 0.00313	1-80 0.0125	1-16 0.06214	1-8 0.125	5-8 0.62137	1	1.152	.....Miles
Knots (U. S.)...			1-73,000		3-20,000 0.00016	1-2000 0.00049	1-1850 0.00054	1-370 0.00271	1-92 0.01085	1-19 0.05396	1-9 0.10855	7-13 0.53959	7-8 0.8684	1	Knots ...(U. S.)

NOTE—At the point where any vertical column crosses any horizontal column will be found the value of the unit named at the head of the vertical column expressed in terms of the unit named under A opposite the horizontal column. Thus, 1 meter = 1.0936 yards; 1 foot = 0.3048 meter.

A Private Plant Shows Large Saving

By Thomas Wilson

SYNOPSIS—Replacing central-station services, including lighting, power, heating and refrigeration, an isolated plant serving two office buildings effected a saving estimated at from $25,000 to $40,000 per year.

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In one of our large cities there are two office buildings under the same management and of nearly the same size. One has been built for several years and has been served with central-station heat, light, power and some refrigeration for cooling the drinking water. The other, a new building, has a plant of its own, which will also serve the older building as soon as its contract expires. Operating-cost data on the two are available so that a comparison should be interesting.

Load in the New Building

The new building is equipped with 200 kw. in lamps, 29 motors for general use ranging from 3 to 60 hp. and nine elevator motors totaling 230 hp. Auxiliaries such as pumps and fans are driven either by motor or by steam, the proportion being about half and half. During the winter months the load runs close to 2200 kw.-hr. per day and in the warmer months, 1800 kw.-hr., so that the average for the year will be about 2000 kw.-hr. per 24-hr. day.

For heating there are 47,000 sq.ft. of direct radiation and for ventilation 16,000 sq.ft. of indirect surface. In zero weather this amount would require close to 450,000 lb. of steam per 24 hr. There would be available from the generating units, assuming a water rate of 40 lb. per kw.-hr. due to the fluctuating load caused by the elevators, 82,000 lb. and more from the steam pumps. It is thus evident that all of the exhaust can be used for heating and for hot water, and in the colder months, considerable live steam in addition is required. There is also a 30-ton absorption refrigerating plant which operates on the exhaust steam from the brine and aqua pumps.

Plant Equipment

The plant installed for the two buildings consists of four 350-hp. water-tube boilers equipped with underfeed stokers and forced draft. There are five 200-kw. units consisting of simple four-valve engines and three-wire, direct-current generators. For supplying the new building with steam it has been necessary to operate only one boiler. In the winter it is overloaded 40 per cent., during the spring it is run at rating and in the summer it is underloaded. When the older building is taken on the load will be nearly doubled, so that at least two boilers will be kept in service. Due to the heavy peaks imposed by the elevators, it is necessary to keep two generating units in operation, although one could carry the load the greater part of the time. It is evident that there is plenty of reserve capacity and that at present the plant is operating under unfavorable conditions.

Records from the Older Building

The older building has a total connected motor load of 426 hp., and the greater part of this, 310 hp., is required by three motors driving elevator pumps, as the elevators are of the hydraulic plunger type. There is a 25-hp. motor for a pump serving a freight lift, a total of 50 hp. in six motors driving ventilating fans and a number of small motors for other purposes besides the lighting for corridors, the power plant and for the tenants.

Last year, the total electrical supply for power, including power-plant and corridor lighting, which goes with the building, amounted to 463,022 kw.-hr. To the tenants, who are supplied individually by the power company, and additional 88,461 kw.-hr. was delivered for lighting. The total is 551,483 kw.-hr. per year, and dividing by 300, gives 1838 kw.-hr. per day of 24 hr. For an average the year around the load closely approximates that of the new building.

For heating, 38,000 sq.ft. of direct radiation has been provided, and steam is now supplied by the central station at a pressure of 5 lb. Hot-water service is required 12 months in the year. For 1913 a total of 22,700,000 lb. was used. As the total electrical load for the year was 551,483 kw.-hr., assuming an engine rate of 40 lb. per kw.-hr. due to the fluctuating load, there would be available

$$551{,}483 \times 40 \times 0.93 = 20{,}515{,}167 \textit{ lb.}$$

of exhaust steam. All of this would not be available in the heating season but the demand for live steam would be greatly reduced and the cost of heating would be only a small fraction of the present charge.

Probable Saving over Central-Station Service

Running under the present unfavorable load, the plant in the new building is producing steam for 20c. per 1000 lb. When the load of the older building is added it is believed that the cost will be reduced to 18c., as the same labor and overhead charges will be divided over a larger output and the plant should run more efficiently. The rate for steam charged by the central station is 37.5c. per 1000 lb., so that even if live steam were used entirely, service from the plant in the new building would save the older building 19½c. per 1000 lb., or $4426.50 for the year, out of a total of $8512.50 now paid the power company.

Of the 22,700,000 lb., assume that 20,000,000 lb. is required in the seven months of the heating season. As the electrical load is divided into 463,022 kw.-hr. for power and 88,461 kw.-hr. for lighting, and most of the power load is due to the elevators, the monthly demands for current will be practically uniform. Thus about seven-twelfths of the exhaust steam will be available for heating, which amounts to

$$\tfrac{7}{12} \times 20{,}515{,}167 = 11{,}967{,}181 \textit{ lb.}$$

Deducting this from 20,000,000 leaves a demand for live steam of 8,032,819 lb. At 18c. per 1000 lb., this would cost

$$8033 \times 0.18 = \$1445.94$$

The difference between this figure and the $8512.50 now paid the central-heating station represents an annual saving of $7066.56 on the heating alone.

The power load of 463,022 kw.-hr. per year is bought from the central station at a rate averaging 2.5c. per kw.-hr. The rate for the lighting load of 88,461 kw.-hr. divided among the tenants is 12c. per kw.-hr. for the first three lighting units and 4c. thereafter. Dividing the total cost by the total consumption gives a rate of 9.2c.

With the combined load of the two buildings, it has been estimated that current can be produced at 1.7c. per kw.-hr., including both operating and fixed charges. On the power load of the older building it would be possible then to save 0.8c. per kw.-hr., or

$$0.008 \times 463{,}022 = \$3704.18$$

Assuming that the current for lighting is supplied to the tenants at cost, the total annual saving by supplying the older building from the private plant would be

$$\$7066.56 + \$3704.18 = \$10{,}770.74$$

This does not include the small saving that might be effected on refrigeration nor does it take into account the possible contingency of supplying the tenants with current at the same rate that they are now paying. In this event there would be

$$88{,}461 \times (0.092 - 0.017) = \$6634.58$$

to add to the profit side of the ledger, making a grand total per year of $17,405.32.

To have supplied the new building, with its slightly greater electrical load and more steam required for heating, with central-station service under aproximately the same conditions, the cost would have been more than double, so that the private plant means from $25,000 to $40,000 per year in the pocket of the management, depending upon the disposal of the lighting rates. The above figures would warrant an investment in power-plant machinery of $200,000 to $320,000 over the equipment that would be needed in the event of central-station current. It is small wonder that a private plant was installed.

* * *

Determination of Engine Clearance

By H. F. Godeke

Engine clearance has been variously defined, but for technical purposes there can be but one definition: It is the volume in the cylinder that is not swept through by the piston and includes the volume of the ports and that of the drips and indicator piping up to the cocks, for the particular end under consideration. Clearance should never be confused with clearance length or clearance distance; these mean the distance in inches between the piston and the cylinder head when the engine is on dead center. Clearance is volume, not a linear dimension. The volume represented by this distance is a part of the clearance, but it also includes the other parts mentioned.

Clearance is often expressed in percentage. This per cent. is the ratio of the clearance volume for one end to the volume swept through on that same end. Thus for the engine crank end, it is the ratio (expressed in per cent.) of the clearance volume to the crank-end piston displacement which, of course, is corrected for the piston rod. Clearance is seldom the same for the two ends of the cylinder, therefore it should be determined for each end separately. This is found by several methods, viz., measurement of openings and computation of volumes, filling the spaces with a plastic substance, such as putty, and then getting the volume by the displacement of an equal volume of water or other liquid, whose density is known, and again by filling the voids with a liquid such as water or oil. The last, the volumetric method, is probably the most practical as well as the most accurate.

The engine should be put on the center and the clearance volume filled through the indicator connection, the weight of the liquid necessary to fill the space being determined by the difference in weight of the vessel and the contents before and after filling. The engine can then be turned over until the crosshead has traveled one inch from the dead-center and the weight of the liquid required to fill the additional inch of the cylinder be determined as before.

If W is the weight necessary to fill the clearance volume;
W' the weight necessary to fill the additional inch, and
L the length of the stroke in inches, then,

$$\textit{the percentage of clearance} = \frac{W \times 100}{W' \times L}$$

Care must be taken to see that there is no leakage and that no air is pocketed in the cylinder. In a fairly tight cylinder, with the valve seat covered by a sheet of packing under the valve and the inside of the cylinder well lubricated, water may be used. Generally, oil is much more satisfactory, the writer having found cylinders which could not be made tight against water to hold oil satisfactorily.

Methods of correction have been offered in case of leakage, the most common being to take the time required for filling the clearance volume and then, after the space has been filled, to keep it filled for a definite time, say one minute. Since the leakage is zero, when starting to fill and maximum when the space is filled, the average rate of leakage is then assumed to be half of that when filled. This average rate is multiplied by the time required to fill originally and then subtracted from the weight needed to fill the space, thus giving the net amount necessary to fill the clearance.

The writer objects to this method because he does not believe the leakage follows a straight line curve. There are two factors which govern leakage, viz., head and opening, both of which increase as the space becomes filled. Necessarily the curve must be a second-degree curve, so that the average leakage rate during the time of filling the cylinder will be less than half the maximum rate. The one solution then is to use some liquid heavy enough to prevent leakage.

Some time ago the writer wanted to know the clearance of the cylinders of a cross-compound, steam-driven air compressor and the makers were unable to give any data. The clearance could not be had by measurement without taking the entire machine apart; neither could the volumetric method be used directly, because the indicator connections were on the side instead of on the top of the cylinder. The indicator piping was removed and a nipple, with a piece of 3/4-in. rubber hose long enough to reach above the top of the cylinder, connected to the indicator tap. A small steel tube was put down through the hose and so bent as to reach the top of the cylinder, the purpose being to draw the air from the top of the cylinder as the liquid was poured in.

With the engine on dead center the piston would not allow the tube to enter, so the engine was turned over until the piston was ¼ in. from the end of its travel, the necessary correction for this additional volume being made later. Water was first tried as a liquid, but it was impossible to fill the volume, because of leaks. Engine oil was used with no leakage whatever. Proceeding as stated, the volume of the space was obtained. The following corrections then had to be made: First, the volume occupied by the steel tube had to be added to that as determined, the volume of the hose and nipple had to be subtracted and that of the indicator piping up to the indicator cock had to be added. This method is simple and gives results that are quite satisfactory.

* *

Home-Made Gas Analyzer

By E. J. Saxe

No instrument is of greater value to the operating engineer than the gas analyzer. In no other way can he learn how to improve the furnace performance with the same certainty. As the cost of the cheapest is sometimes prohibitive, it is here intended to show how anyone can, with little trouble and at small expense, make an analyzer that, while lacking the finish of the factory-made instrument, will give good results, which is the main point.

The writer at one time carried an Orsat appartus, but in extended traveling frequently broke bottles which could not be replaced in a small town. To get them from Chicago was expensive and the time lost was a matter of still more importance. Finally, a rig was devised of material to be had at any drug store. A similar one may be made by anyone who will procure from a dealer of such instruments a 100-cubic centimeter burette having a 50-cubic centimeter bulb (as the tube and the case are shorter than otherwise). Fig. 1 shows the case, which can be made of any material to suit individual taste. With the burette purchase a glass three-way cock, six feet of small glass tubing, six feet of ¼-in. rubber tubing, and two pinch clamps; this will cost about $5.

From a druggist get three 6-ounce bottles, and an ounce of half spirits of camphor and half turpentine, break off the tip of a small round file, wet it in the mixture and drill a hole in each bottle near the bottom. A breast drill can be used, or the file may be revolved with the fingers; drilling a hole in glass this way is not difficult. When the file end gets dull, break off a small piece and it will again cut rapidly. File the hole smooth and round and of such size that the rubber tube will fit tightly and be water-tight. Connect the two bottles as shown in Fig. 2, and fill one of them with the glass tubes, broken to lengths to go inside (shown in the shaded bottle). This is the absorption bottle. The tubing is to provide a larger wetted surface, and consequently a more rapid absorption of the gas. The other bottle is to hold the solution when it is driven out of the first bottle by the gas to be tested.

In this first bottle place a rubber stopper, having a glass tube through it. It should project about a half inch on each side of the stopper to attach the rubber tube on the outside and the lower end serves as a gage for the solution when in use.

If it is desired to test for CO and O, three such pairs of bottles must be made and a different solution used in each, but for ordinary use the CO_2 test is all that is needed and the engineer can generally tell whether a small per cent. is due to too much or too little air.

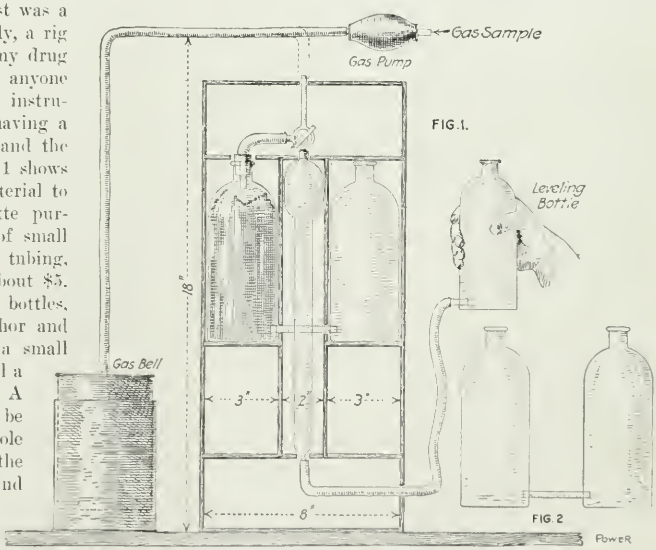


Fig. 1. Assembled Unit Fig. 2. Bottles Connected

Join the burette and absorption bottle with the three-way cock with rubber tubing as shown, and connect the other bottle with the bottom of the burette by 18 inches of the rubber tube for a leveling bottle. Fill the absorption bottles half full of a solution of caustic potash and water as strong as can be made. Then proceed as follows: Fill the leveling bottle with water, open the three-way cock to the atmosphere and raise the leveling bottle to fill the burette with water. Next turn the three-way cock to connect to the caustic bottle and lower the leveling bottle until sufficient water has run out of the burette to raise the caustic solution in the first bottle to a point where it just touches the glass tube in the cork. Turn the three-way cock to cut off from the caustic, open to the atmosphere and again fill the burette with water by raising the leveling bottle.

You now have 100 cubic centimeters of water in the burette, and the first absorption bottle is full of the caustic and the other bottle is nearly empty. Now all is ready for the gas sample. Make a gas bell out of two tin cans, one of which will easily slip inside of the other. In the bottom of the smaller one solder a short spout to which to attach the rubber tube and fill the larger can with water. Put the smaller into it bottom up, so that it will be completely filled with water and all air excluded. Put a piece of quarter-inch gas pipe through the boiler setting at the point where you wish to obtain the sample, taking care to avoid dead spaces and corners. To this pipe attach the tube and bulb of a cheap syringe, which answers as a gas pump, and pump a sample of gas into the gas bell. It is well to pump some gas through the bell to make sure that all air in the pipe and tube has been expelled.

Having obtained the sample, next connect the gas bell to the burette, and draw the water down to the zero mark (by lowering the leveling bottle). You have now drawn off 100 cubic centimeters of water and the gas has taken its place.

Turn the three-way just enough to shut off from the atmosphere without opening to the caustic and disconnect from the gas bell; open the three-way to the atmosphere for an instant. This will relieve any pressure above the atmosphere that may be on the gas. Then turn the three-way to connect the burette with the caustic bottle. Raise the leveling bottle so that the water will drive the gas over into the caustic bottle, then lower the leveling bottle and draw the gas back into the burette. Repeat this operation two or three times. Now, finally draw the gas back into the burette until the caustic just touches the glass tube in the cork, as in the beginning, and turn the three-way to close from both atmosphere and caustic. Then raise and lower the leveling bottle until a place is found where the gas is free from compression or expansion, and the amount that the water now stands above zero on the graduated scale is the per cent. of CO_2 absorbed.* With a little practice, these tests can be made rapidly.

A sample of gas from just back of the bridge wall under the boiler should show 12 to 16 per cent. If it does not, look at the fire and see that the grates are all covered, i.e., no holes in the fire. Then try different thicknesses until this per cent. is obtained. Next take a sample at the back end of the combustion chamber or at the uptake. If the CO_2 is less the farther you get from the fire, it is due to air infiltration and the obvious remedy is to get after the cracks.

Just what this air leakage means can be told by the following table:

% CO_2	2	3	4	5	6	7	8	9	10	11	12	13	14
% Loss	90	60	45	36	30	26	23	20	18	16	15	14	13
% Efficiency....	10	40	55	64	70	74	77	80	82	84	85	86	87

After this a draft gage will be needed. With a blow torch, heat a piece of glass tube 8 inches long to a cherry red and bend it in the form of a hairpin. Fasten it to a board and mark off a scale of inches divided in tenths on a card, and the difference in the water level in the two legs is an indication of the vacuum. Try different draft pressures and after observing the effect on the CO_2 readings, a decided saving in coal will be noted.

As the boss should know what has been done, make him a neat looking statement of what all this means in dollars and cents per year. He will be interested, though he may not seem to be, and it will surely have its effect in time.

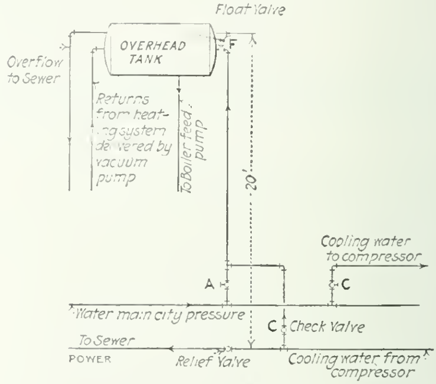
Saving Cooling Water

By T. W. Reynolds

The sketch shows an arrangement of piping whereby the cooling or jacket water from a compressor was saved and delivered through a float valve into an overhead receiver from a heating system.

Only a small quantity of makeup water for boiler purposes was required, therefore the water from the compressor could not be continuously discharged into the receiver without wasting part of the heat of the return water by the overflow from the receiver discharged to the sewer.

To avoid wasting this cooling water when required as makeup, an arrangement was made as shown, whereby it is discharged into the receiver when the float valve *F* is open. When this valve is closed the jacket water, which is at city pressure, is automatically discharged to the sewer through the relief valve.



Arrangement for Saving Cooling Water

When the compressor is not running, valve *A* is opened, admitting a direct supply of city water to the receiver.

The relief valve should be so adjusted that it will open to the sewer at slightly over 10-lb. pressure. This will allow for the static head of 20 ft. to the tank. Otherwise the water would pass through the line of least resistance, i.e., through the relief valve to the sewer, rather than raise itself to the elevated tank.

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Knurled Pipe-Cutter Wheels

The Nye Tool & Machine Co., Chicago, Ill., has recently developed a pipe cutter fitted with a knurled-edge cutter wheel in place of the usual plain, sharp-edge disk wheel. The teeth are knurled diagonally and remove metal during the cutting process instead of upsetting it, as is done by the ordinary disk wheel. Friction is, therefore, reduced and large pipe can be cut with less effort. The knurled wheels are made in sizes and styles to fit any regular make of holder on the market.

⁂

Draft Valve—Each quality of fuel used requires a special draft value. For run-of-mine bituminous coals an average of 0.01 in. of water is allowed for each pound of coal fired per hour. Thus two 300-hp. boilers having a total of 106 sq.ft. of grate area and burning 20 lb. of fuel per sq.ft. per hour would require a draft of (20 × 0.01 in.) = 0.2 in. The draft actually used will generally be from two to five times that really required.

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*The illustration should show the graduations on the burette tube from zero near the bottom to 50 at the top. The pinch clamps referred to are for use on the rubber tubing to stop the flow of gas.

Editorials

No Place for the Central Station

The central station has a legitimate field to which it can supply electrical energy at a cost lower than it could be produced individually by its customers. But a large office building requiring steam for heating, and perhaps refrigeration, is far removed from this class, as with an uptodate isolated plant and efficient management the various services can be supplied at a cost lower than any legitimate charge made by the central station.

It is true that the cost of generating current in the central station is usually less than in a small isolated plant, but the cost of distribution and the overhead charges attached to the former are so heavy as to more than wipe out any advantage gained in the engine room. In obtaining large business it is quite customary for the central station to omit all, or the greater part, of these last two items from the charge to the consumer and make it up by exorbitant rates to the small customer, but even then the steam which must be generated for heating presents an insurmountable obstacle.

Why then are so many buildings purchasing current? If the truth were known, many of them are controlled through interlocking financial interests. Then again there are owners who will listen to plausible solicitors and sign contracts with but little knowledge of what they are doing. The combined cost of electrical service and heating, however, soon presents evidence which is undisputable.

A noteworthy example of an isolated plant which has effected a large saving is cited on other pages of this issue. The names and locations of the buildings are withheld due to a request by the owner, but the facts and results obtained are presented. The results are specially interesting as there are two buildings, of nearly the same size and requirements, one supplied with central-station service and the other containing an isolated plant, although this condition will exist only until the central-station contract for the older building expires.

With the older building the owner made the common mistake of installing central-station service, not only for lighting and power but for heating and some refrigeration as well. Paying the bills for these different services was an excellent schooling, and when the new building went up a private plant was installed.

For central-station charges on the loads carried, the rates were not excessive, thirty-seven and one-half cents per thousand pounds of steam and two and one-half cents per kilowatt-hour, yet a large saving was effected. The private plant is capable of producing high-pressure steam for eighteen cents per thousand pounds, and by using the exhaust from the generating units, the demand for live steam is greatly reduced. In fact, the annual saving on this one item in the older building amounted to more than seven thousand dollars. Including interest, depreciation and all operating charges, and making no allowances for the utilization of exhaust steam, current can be generated for 1.7 cents per kilowatt-hour, as compared to the 2.5 cents charged by the central station.

To the saving in the older building this difference added nearly four thousand dollars, and sixty-six hundred more if the private plant furnished current to the tenants at the price made by the central station. Neglecting the last item, the estimated saving in the older building totals nearly eleven thousand dollars. It should be more in the new building even after allowing for some decrease in rate due to the larger demand. A saving of twenty-five thousand dollars per year on the two buildings is a conservative estimate.

Many office-building plants of various sizes in the country are making good, and their records would no doubt be available to those really interested. In these days dividends from office structures are not so large as to warrant throwing away several thousand dollars per year. Whether to buy or make current is a question worth investigating, for generally the building owner will save money by installing an isolated plant.

Industrial Education Again

We commented on this subject editorially in our issue of July 28, and are minded to mention it again because of two references to it in this number. Mr. Dixon in his letter, "Industrial Education—a Warning and a Hint," on p. 689, says many things in which we concur, howbeit his criticism is a bit sweeping and in parts rather cynical.

Incidentally, we take exception to his characterization of "safety-first" propaganda as hypocritical. While unquestionably the movement is a fad with some, and there are those identified with it for selfish purposes of their own publicity, the fact remains that it has its origin in a real need and its value is so important that it deserves emphasis by whatever means may happen to be employed. We have added our comments whenever they seemed called for and shall continue so to do while those responsible for public welfare and safety persist in evidencing a disposition to be careless or reckless.

To return to the subject in hand, we endorse the work recounted under "Engineering Affairs," p. 696, undertaken at Pratt Institute to train practical mechanics as teachers of their several trades. This course approaches the problem in so eminently logical a manner that we believe it will have the approval of all interested in securing the best results from industrial education.

Without detracting from the advantages of the study of pedagogy to all who enter the instructing profession, we submit that, at least so far as trade school work is concerned, it is easier to impart enough of the teaching art to those already experienced in the mechanic arts for them to become efficient trade teachers than to supply the lack of practical shop or power-plant experience to those whose main qualification is a knowledge of educational methods. We look for a large success for the course initiated at Pratt Institute and hope to see the instructing staff of industrial schools mainly recruited from the ranks of men who have received such training.

The main theme, as we read it, in Mr. Dixon's argument is that the mere earning of a living should not be the whole purpose of educational training; naturally, industrial schools form the only class of educational institutions that need this warning. A basic idea of such schools is to eliminate waste time in unnecessary studies, but if the instructors are guided only by the motive of equipping their students to earn a living, they err, in Mr. Dixon's judgment. However, is it not likely that, if the teachers are drawn from the field in which they are teaching others to serve, they will sense all the needs of the workers in that field sufficiently not to exclude the training which will enable them to derive the greatest enjoyment and satisfaction in their chosen sphere of activity?

Granted that the country needs not simply workers but thinkers and good citizens, the problem resolves itself into the difficult one of deciding how far the industrial schools should go in endeavoring to inculcate the broader principles of useful citizenship into their students. If they are at present leaving too much to the chance that the individual student will develop properly by instinct, home influence, or contact with his fellows in the broad school of life, what can they do to remedy this defect? The best suggestion we can offer is that the instructors be carefully selected for their professional success and general integrity. The rest can be left to their wisdom to adopt the best instructing methods and to their example to inspire their students.

A Gag on a Safety Valve

As stated on page 695, the lever of a safety valve on a high-pressure boiler was held down by a prop under the sidewalk. It seems incredible that such a thing should be done in the heart of a city, on a large boiler located directly under the sidewalk around a hotel, on the corner of two busy thoroughfares. Overloaded safety valves in out-of-the-way places probably do exist, but in a city and a plant in charge of licensed engineers, day and night, a hotel full of guests, with café and dining room patronized by hundreds and the sidewalks traversed by thousands daily, it is almost beyond belief.

Aside from the gag on the safety valve, there was but one relief valve attached to the boiler. This circumstance emphasizes the need of an auxiliary spring loaded valve, which can be locked when properly set so that it cannot be tampered with. Such a valve should be required on all boilers (as it is in several states and some provinces in Canada). There was no convenience for lifting the lever of the valve and, as its location and surroundings made it almost inaccessible, it is likely this was seldom done. It may be easily credited that the daily test as well as allowing the valve to blow from over-pressure were objected to on account of the noise and other annoyances. Was the gag put on for that reason?

Then again, this boiler was not equipped with a fusible plug to give warning in case of low water. Surely such an inexpensive safeguard should not have been omitted.

The method of putting in the new tubes is seriously questioned. The previous set had been rolled several times during its time of service and the holes in the tube sheet were considerably enlarged as a result. If the holes were stretched more on the inner than on the outer side of the sheet, the staying effect of the tubes would be almost nil. This, together with the fact that the new tubes were not beaded over or even flared on the outside, would cause the head to receive the strain unaided. The total load on a head of such diameter might easily be beyond the resistance of the unsupported sheet.

Specific instructions as to the proper method of expanding tubes into the headers of water-tube boilers, and which are equally applicable to other types, appeared on page 245 of the Aug. 18 issue, written by E. H. Wells.

The use of shims, especially thick iron ones, has more of the look of a patch job to make undersized tubes do than first-class fitting. As a matter of fact, they are often used, but the tubes should be flared or beaded over them.

Local regulations should certainly be more stringent and more inspectors should be added to the boiler squad to make closer supervision possible. Don't forget that thorough and efficient examinations and inspections before accidents bring better results than the same work after an accident.

The War and the Fair

Commend us to the optimist every time. We have to admire the chap who faces a dismal outlook with a grin even if it is forced. So we say "Hats off!" to the publicity department of the Panama-Pacific Exposition for making a statement like this:

> There is nothing in the present situation that seems likely to affect seriously the success of the exposition.

The best part of it is that after so bold a declaration they still have the courage to back it up with the following reasoning; which certainly does "listen well":

> Any possible loss of exhibits from countries involved in war, if it occurs, will be balanced by an increase from other directions. The effect on attendance, if any, is likely to be favorable rather than otherwise, what is lost in attendance from Europe being ten times compensated for by Americans coming here instead of going to Europe.

Further, they claim that the war will turn "hundreds of thousands" of tourists from North and South America to the exposition instead of to Europe. An official says:

> The war in Europe will offer a great opportunity to American manufacturers. One of the contending European nations has controlled 70 per cent. of the South American trade. This war will force that trade upon us and force Latin-Americans to visit this country. It has been impossible for the American manufacturers to invade the commercial fields held by Great Britain and Germany in Latin America.

And he goes on to say that under the conditions the English and German nations will

> find it necessary to make a strenuous effort at the exposition to retain their trade, which previous to the crisis they considered secure, and, above all, the exposition will be the beneficiary of the unprecedented prosperity of the Middle West resulting from their bumper crops and war prices.

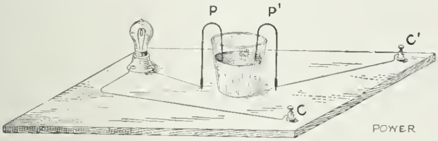
Enthusiasm and loss of heart are both infectious, so a gloomy prospect may be improved by such talk, and surely will be aggravated by the other kind. Therefore, those who insist on believing that the war will make prices high so that those in moderate circumstances will have to economize and forego unnecessary travel, especially to world's fairs where nothing is cheap, or who think that nations at war have enough of a job on their hands and no time or money to devote to preparing exhibits, should keep such thoughts to themselves.

Let us show the world that we can make a success of the Fair in spite of the unfavorable conditions.

Correspondence

Determining Polarity

The sketch shows a simple means of detecting polarity in a direct-current circuit. It consists of a wooden board upon which is mounted a 16-cp. lamp and socket, in circuit with two terminals *C* and *C′* and two pieces of fusible wire *P* and *P′* which project into a glass containing water with 8 or 10 drops of sulphuric acid.



Simple Means of Determining Polarity

When the terminal posts have been connected to the circuit the lamp will light and bubbles will appear in the glass. Within a short time, one of the leads in the water will become brown and the other a bright gray. The former will denote the positive and the latter the negative wire.

F. P. Ampudia.

New York City.

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Pump-Motor Troubles

A three-stage pump, driven by a compound, direct-current, variable-speed motor, handling drainage water in a mine, gave trouble by taking too much current and tripping the circuit-breaker in the power house when the speed was increased to give the required head. At first it was thought to be due to stoppage at the inlet of the pump. Accordingly, the casing was opened several times and the parts examined, but they were free and properly assembled.

The machine was a mile from the power house, and had over 300 ft. of lift. The motor was started in the usual manner with full field, the speed being increased by weakening the shunt field until the pump began to deliver water. The slight rise in speed necessary to increase the flow resulted in a heavy increase in current, causing the circuit-breaker to go out.

Several trials convinced me that the trouble was due to a wrong series field connection, for when the motor was brought up to speed by weakening the shunt field, the series field became stronger by the increased current until at a certain load it overcame the shunt field, and, being in the opposite direction, tended to reverse rotation with the results as noted. Accordingly, the series field connections were reversed, after which the machine was put into service and took only normal load current.

In another instance a small three-phase motor driving a centrifugal pump heated excessively when first put in service. An ammeter in the line showed overload current, and, believing the trouble to be caused by over capacity of the pump on account of the nature of the liquid handled, the piping was changed so that a test for head and capacity could be made. This showed the motor to be a little overloaded, but not enough to account for the excessive current.

A wattmeter connected in the lines near the motor showed that the trouble was due to the auto-transformer used in starting. All three lines were closed when in the starting position, but in the running position one line was open because of a broken contact finger. This was repaired and the motor operated satisfactorily.

William Salt.

Trenton, N. J.

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Gaskets for Plugs for Compressor Valves

We are having trouble in keeping the plugs tight on the valve bonnets of an ammonia compressor. Lead gaskets have been tried made of one part bismuth, one part tin and twenty-five parts lead, but these were too soft and would not hold; they seemed to melt away.

As the machine is old-style, we do not know what kind of gaskets were used originally. Recently the valves were reseated and the repair man did not use the correct gasket material when he put the plugs on. Will readers please advise what material we should use for these gaskets?

Christian L. Herr.

Lancaster, Penn.

⁂

Simplifying Reports of Boiler Tests

A report of a boiler test should interest any business man who has, or expects to have, a boiler. If we address a report of any kind to an audience, we use the language of that audience rather than our own; we address the English in English, the French in French, the Chinese in Chinese. Therefore, we should address a report to the public in language used or understood by the public.

Many boiler plants are under the management of busy and brainy men, who are not, however, chemists, physicists or engineers. Such men become lost amid the confusion of unnecessary technical phrases, fail to distinguish between what are apparently slight shades of expression, and finally give up all idea of understanding reports which, though meant for them, are written in an unfamiliar language. Hence it is often impossible for them to compare one boiler test with another and arrive at any satisfactory conclusion.

A boiler-test report will contain one or all of the following expressions:

1. Actual evaporation per pound of coal as fired.
2. Actual evaporation per pound of dry coal.
3. Actual evaporation per pound of combustible, mechanically obtained.

4. Actual evaporation per pound of combustible, chemically obtained.
5. Equivalent evaporation per pound of coal as fired.
6. Equivalent evaporation per pound of dry coal.
7. Equivalent evaporation per pound of combustible, mechanically obtained.
8. Equivalent evaporation per pound of combustible, chemically obtained.

Is it any wonder that the business man throws up his hands in despair? Eight expressions, all much alike and all different! Can we blame him if he is prone to consider his engineering brother as pedantic and fond of splitting hairs?

The expression, "a pound of coal," is used by the engineering fraternity as though coal were a definite and fixed compound of unvarying mixture and heat value. All of these things coal is not, and neither is combustible, so that after using such expressions we, of the engineering profession, clear up our own conscience by other expressions, which, while clear to us, are equally maddening to our clients. What does the "efficiency of boiler, furnace, and grate" mean to them, and what difference can they see between that and the "efficiency of boiler and furnace?"

The Bureau of Mines, Bulletin 22, gives the analyses of coals of the United States, the heat values ranging from 5000 to 15,000 B.t.u. per pound. This shows that "a pound's a pound the world around" does not apply to coal, as the burning of a pound of one grade will make as much steam as the burning of three pounds of another grade.

When a certain amount of coal is fed onto the grates, the ash, slate and other refuse, and such of the coal as falls through the grates, are not burned. This unburned material may all be weighed and the weight of the burned material thus ascertained. This actually burned material is called the "combustible." A pound of it, however, will have as wide a variation in heat value as the coal itself. A pound of "combustible" is therefore a meaningless term.

It is true that the engineer makes a report of two kinds of efficiency, one based upon the heat value of a pound of "dry coal," the other upon that of a pound of "combustible." The theory is a beautiful idea that all the weight of coal fired except the moisture and the residue which has fallen through the grates, passes off from the grates in a combustible form and that it is the duty of the furnace and boiler to utilize as much as possible. The grate itself is exonorated from responsibility in connection with the utilization of this "combustible" and the efficiency which is based upon it is called by engineers "the efficiency of furnace and boiler." The other efficiency, which is based upon the heat value of the "dry coal," is arrived at by considering that it is the duty of the three essential parts (grate, furnace and boiler) to utilize as much as possible of the potential heat furnished them as coal.

These two distinctions are unnatural and misleading. The grate cannot thus be irrationally separated from the furnace and boiler. The ratio of the potential heat in a pound of dry coal to the heat actually developed per pound of dry coal is not unequal to the ratio of the potential heat in a pound of coal as fed, to the heat actually developed per pound of coal as fired. Why, then, refer to dry coal?

If coal drops through the grates unburned, or only partially burned, it may be due more to the construction of the furnace over the grates than to the grates themselves. On the other hand, volatile matter may be separated from the fuel and be included as part of the combustible for which furnace and boiler must account, whereas it will really pass up the stack unburned on account of inferior grate construction. Or the entire boiler may be cooled off on account of the grates allowing too much air to enter. It is clear then that the efficiency of the grate cannot be independently established and that any report of efficiency must include it, as well as the large factor of the efficiency of the fireman, who may handle most efficient apparatus inefficiently or *vice versa*.

In considering or comparing any boiler efficiencies, it is well to remember that no two boiler tests can be compared truly and absolutely one with the other on account of this human element, and that behind extremely high efficiencies there may stand skillful firemen.

Another troublesome expression to the ordinary business man is "evaporation from and at 212 degrees." He can conceive that more heat is required if the water is fed in a colder state and that less will be required if the temperature, or pressure, of the steam is reduced. He can conceive therefore that a certain feed and a certain steam temperature may be used as a "standard" in order to compare one evaporation, or production, of steam to another.

To sum up, the use of expressions admittedly meaningless, variable, or difficult for the laity to comprehend, is a needless impediment. Evaporation "from and at 212 deg. F." may be expressed as "standard evaporation," the meaning of which any ordinary man will grasp. In like manner, true comparison of one test with another requires a "standard fuel." Say, for instance, any weight of any fuel containing 10,000 B.t.u. comprises a pound of "standard fuel." Bearing these ideas in mind, the report of a boiler test can be greatly clarified and condensed. Any report of moisture, ash, refuse or combustible is discarded as these factors are automatically cared for by the use of a "standard fuel." Conditions of ash, slate, moisture, etc., are elements of a report of a fuel test, anyway, rather than a boiler test.

While the adoption of these views would result in a "simplified report of boiler tests," as given herewith, one readily understood by engineers and laymen alike, yet the essential commercial results which the business man wishes to know comprise only the efficiency of the boiler and the capacity of the boiler while showing that efficiency; or *vice versa,* the capacity of the boiler and resulting efficiency. For fuels of a similar nature, these results are independent of every condition except the skill of the fireman; and by these results alone can one equipment and operator be compared to another equipment and operator. Efficiency should be based only upon the coal as fired, or should express the relation of output to input.

If I were a business man, I would eliminate the noncommercial items of a boiler report entirely and would wish to know only four things about a boiler test:

1. The kind of fuel used.
2. The skill of the fireman.
3. The capacity during test.
4. The efficiency during test.

I should want tests made, to secure as great a capacity as possible and to know at what per cent. of rating the best efficiency was secured and what overload I could carry.

Below is given a simplified report for a boiler test, one containing all facts essential to the engineers, also a condensed commercial report containing facts essential to the business man:

SIMPLIFIED REPORT OF BOILER TESTS

(10,000 B.t.u. taken as a pound of "Standard Fuel"; 970.4 B.t.u. taken as a pound of "Standard Evaporation.")

General:
   1. Test to determine..................................
   2. Test conducted by..................................
   3. Date of test..................................
   4. Duration of test..................................
Fuel:
   5. Kind of coal..................................
   6. Name of mine..................................
   7. Size of coal ....
   8. Name of fireman..................................
Boiler:
   9. Kind of boiler..................................
   10. Water heating surface..................................
   11. Superheating surface..................................
Furnace:
   12. Kind of furnace..................................
   13. Height of furnace..................................
   14. Length from rear end of grates to heating surface....
Grate:
   15. Kind of grate..................................
   16. Area of grate..................................
   17. Per cent. of air space in grate surface...............
Average Observations:
   18. Steam pressure by gage..................................
   19. Temperature of feed water entering boiler............
   20. Temperature of gases leaving boiler.................
   21. Force of draft between damper and boiler.............
   22. Force of draft in furnace..................................
   23. Quality of steam..................................
Total Quantities:
   24. Weight of coal as fired..................................
   25. B.t.u. per pound..................................
   26. Weight of water fed to boiler..........................
   27. Weight of water actually evaporated..................
Hourly Quantities, Actual:
   28. Coal fired per hour..................................
   29. Coal fired per hour per sq.ft. of grate...............
   30. Water actually evaporated per hour..................
Hourly Quantities, Equivalent or Standard:
   31. "Standard" fuel per hour..................................
   32. "Standard" fuel per hour per sq.ft. of grate...........
   33. "Standard" evaporation per hour......................
   34. "Standard" evaporation per hour per sq.ft. of heating surface ....
Capacity:
   35. Rated evaporation per hr. per sq.ft. of heating surface.
   36. Actual evaporation per hr. per sq.ft. of heating surface.
   37. Rated horsepower..................................
   38. Actual horsepower..................................
Efficiency:
   39. Efficiency, ratio of total heat output to total heat input.

CONDENSED COMMERCIAL REPORT OF BOILER TEST

1. Test to determine..................................
2. Conducted by..................................
3. Kind of equipment (boiler, furnace, and grate)............
4. Kind of coal (class, mine, size)........................
5. Kind of fireman (name and skill)........................
6. Actual horsepower in per cent. of rated.................
7. Efficiency ....

EGBERT R. MORRISON.

Chicago, Ill.

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Industrial Education--A Warning and a Hint

A large part of present education has little reference to life as it is today, either in substance or methods. Yet education should be preparation for life. Professor Dewey, one of the foremost apostles of the new education, says: "It is its business to select whatever is relevant to the most effective carrying on of life's functions, and to arrange what is selected; not on the basis of some outside pattern, but with reference to facilitating the complete practical performance of all the activities possible to an organic being." Let us nail that down. "All the activities possible to an organic being."

Herbert Spencer cataloged these activities as five: Self-preservation; earning a livelihood; society; civic duty; parenthood. The first we may leave to "chambers of commerce" and their hypocritical propaganda of "safety-first." The last is the most important of all. The fourth needs more emphasis than it has had. The second has received too much. Why need we worry about earning a living? Ford's floor sweepers get $1500 a year. It is not difficult to earn that much. The trouble, for most of us, comes in getting it. As Mr. Post used to tell us, "There is a reason"; and though it would seem fitting that the schools might teach us that reason, it is hardly probable that they will until the fact becomes historic.

This line of argument has an economic trend that it may be out of place to pursue here. It should, however, be kept in mind whenever this question is discussed. It is introduced here because so many writers seem to proceed on the assumption not merely that we need a training to enable us to earn a living, but that this sort of training is the whole work of education. It is only natural that the capitalist should make this mistake; it is to his selfish economic interest. The engineer has no such excuse. He should approach the matter in a broad way. Prof. Frank T. Carlton says: "The United States stands at the parting of the educational ways. Is education to be primarily for the purpose of training workers or young men and women? Will the demands of 'big business' or the demands for good citizenship and racial efficiency dominate? Here is the greatest danger in present education."

Mr. Fish, in a recent number of POWER, cites some efforts now being made in certain trade schools to train boys to be operating engineers. It is one of the great faults of these trade schools that they fall into the grave mistake above mentioned. In this matter, it seems to me, they have over-reached themselves. I am a firm believer in education for the engineer, not that it may bring him more money, for it is likely that the same effort in other lines would bring more substantial results, but because it tends to safety, efficiency, and that pleasure in work without which life is hardly worth while. Also, intelligence is always a precursor of liberty, and I believe in liberty. I find several objections to the plan advanced by Mr. Fish.

In the first place, the school cannot even hope to get an equipment that would serve for much more than a toy. In the second, the instructors, with possibly rare exceptions, are unfit for the work. Mr. Fish feels it is impossible "for men to 'fake' teaching, as it is possible in the colleges." The writer has, in recent years, been in rather close contact with both industrial training schools and university work. In the latter there are some men who are "putting up a bluff"; but for pure and arrant faking, commend me to the very sort of trade school Mr. Fish represents. If the trade schools are going to teach engineering, they will have to reorganize. Nor will that be easy. In every large town may be found one or more men well equipped as engineers who would make excellent instructors for men employed in the power plant. To take mere boys and make a success of such work demands other qualities which not one in a hundred of these men possesses. A third stumbling block is to be found in the students themselves. I say this from observation not only in the classroom and the shop, but also in the locker room.

It is bad practice to try to teach a person an idea until that person has a desire to know it—until he realizes the value or necessity of such knowledge. The man who has put in a few months in the power plant is getting into this frame of mind. Then is the time to implant such education as is especially required by the power-plant engineer. The incentive is far greater than that of the boy and the results are out of proportion.

There is no reason why schoolhouses should be closed at 4 p.m., nor why they should be closed to the person over twenty; we all ought to go to school until we are fifty. Here is my plan for the special education of the power-plant engineer: Use the public-school buildings, laboratories, etc., in any town where there is sufficient demand. Hold evening sessions. Admit any actual worker. Make the age limit 100 years. Put on the faculty some engineers who are successful and capable. One advantage of this plan is that we should not be required to wait a generation for results; we can begin now, and results will follow quickly. A united demand in any locality ought to secure its adoption.

William E. Dixon.

Cambridge, Mass.

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Incompetent Repair Men

The other side of the story by G. H. Wallace, p. 499, Oct. 6, under the above title, is the incompetent engineers. I am reminded of some.

In a plant of about 5000 hp. a repair man rebored the valve chambers and refitted the valves of a 1200-hp. Corliss engine. The high-pressure admission valves did not close promptly when running on short cutoff. After the repair man had gone for the night the chief engineer removed the valves and draw-filed them with a coarse file. The valves, of course, worked easier and this operation was cheaper than to overhaul the vacuum dashpots, but the fit was spoiled and the valves leaked. Then the repair shop was blamed for putting a poor workman on the job. This engineer deserved credit for having worked his way up in the plant from coal passer, but he had never worked in a machine shop.

Another time I fitted piston rings to a Corliss engine of about 30-in. bore. The engineer demanded that they bear on the bottom of the grooves so that the weight of the piston was carried by the rings—on the theory that the piston should not bear on the bull ring because the greater bearing surface caused too much friction. I told him that it was not customary and suggested that if the friction was excessive with cast iron, to insert Allan red metal into the undercut grooves in the bull ring. He could not see the advantage of doing it that way, so I went ahead and gave him what he wanted.

An engineer should have sufficient knowledge of machine work to know when a repair job is done right, and before the man leaves the job. If the first man sent does not understand his business, telephone to the shop for one who does.

Albert T. Rowe.

East Glastonbury, Conn.

Referring to p. 499, Oct. 6, when the repairman broke the crosshead shoe and put in a large washer to hide the defect, the engineer was incompetent, to my mind. It was his duty to make the adjustment, but it took him three weeks to discover that the shoe was broken.

In the second case the repair man was blamed for putting the slide valves in wrong. We can hardly expect the average machinist to set all kinds of valves. The engineer must expect to give them his personal attention.

In the third case, the eccentric was not set right. The engineer should have set it himself. Let us hope that such things do not happen where licensed engineers are employed.

William W. Elderkin.

Calgary, Alta., Canada.

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Diagram from New Engines

On page 427, Sept. 22, C. R. McGahey did not state the percentage of load carried at the time of taking the diagrams nor whether the boiler pressures and indicator springs were the same in each case. If he would run a steam-consumption test (not worked out from diagrams), he would probably find that No. 1 was considerably more efficient than No. 2. A little more lead would improve No. 1, but how would it affect the steam consumption which, after all, is the important factor? Perhaps with more load and the governor in a lower position, there would be enough lead, providing the valves are of the non-release type. The compression certainly speaks well for steam tightness.

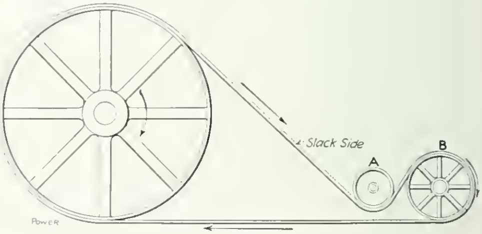
E. R. Pearce.

Rochdale, England.

⁂

Centrifugal Effect in Belts

I wish to add this query to my article on the above subject, on page 892, June 23: Why not use an idler, if necessary, of smaller radius than that of the smaller pulley, to merely hold the belt in position and maintain a negative curve permanently? I see no good reason why it cannot be done.



Idler with Slight Tension Only

For example, in a drive where one pulley is considerably larger than the other, with the belt running very slack, the function of the idler pulley *A* is not as a tightener but merely to guide the belt in a circular path of a radius less than the radius of pulley *B*. It has been demonstrated experimentally at the Technical Institute of Charlottenburg, Germany, that idler pulleys do not add an appreciable drag on belts if they are properly designed and of a radius somewhat larger than that of the smaller transmission pulley. In these experiments, however, the idlers were doubtless loaded rather heavily, in accordance with the usual belief that tension is necessary on the non-pulling side.

It has been my experience that great initial tension is not necessary and is not as important as surface contact; hence, such an idler as proposed would be used simply to keep the negative curve in the belt, prevent it leaving the pulleys by centrifugal force, and losing contact entirely.

W. B. Schaphorst.

New York City.

Inquiries of General Interest

Making Equalizer Connection—In a compound-wound commutating pole machine where is the equalizer connection made?

P. D.

The equalizer connection would be taken off between the interpole and series windings.

Amount of Blowoff of Pop Safety Valve—Why does a steam pop safety valve which is set to pop at 100 lb. pressure continue to blow off until the boiler pressure has become reduced to 80 lb.?

W. A. M.

Most pop safety valves are provided with a blowoff adjusting ring which can be adjusted for securing greater or less assistance from reaction of the escaping steam in holding the valve open. The amount of blowoff of the valve in question is undoubtedly due to the adjustment of the blowoff adjusting ring.

Hammering of Safety Valve—What causes a direct spring loaded safety valve to chatter?

W. N. R.

With properly constructed safety valves, a hammering or chattering is usually due to too great length of pipe connection to the valve. When the boiler pressure is at blowoff pressure and raises the valve, the pressure of steam delivered is reduced by the throttling effect of the pipe connection, causing the valve to rise and fall from alternation of built up and reduced pressure in the pipe connection.

Splitting of Condenser Tubes—What causes brass condenser tubes to split?

G. A. W.

In their manufacture the material of the tube is drawn out into a number of parallel elements slightly varying in thickness and texture according to the processes of manufacture. These cylindrical elements become separated from bending of the tube, as when the tube length expands more than the condenser shell or from difference of expansion of adjacent elements due to their difference of texture, difference of corrosion, or difference of temperature.

Replacing Valve Rod and Eccentric Rod Brasses—How can worn brasses be replaced by new ones on the valve rods and eccentric rod of a Corliss engine without changing the valve setting?

J. B.

Before removing the old brasses of a valve rod, tram the distance from center to center of the pins and carefully lay off the distance on a wooden rod for reference. After the new brasses are fitted in their places, adjust the length of each valve rod to obtain the distance formerly trammed between centers of the pins. To preserve the same length of eccentric rod, set one point of a tram in the center of the eccentric rod pin and with any convenient distance between the tram points, scribe a mark on the eccentric strap casting and transfer the distance to a rod for future reference and after the old brasses have been replaced by new ones, adjust the length of the eccentric rod to the formerly trammed distance from the mark on the eccentric strap casting to the center of the pin.

Bursting Pressure of Boiler—If a boiler 56 in. in diameter is made of ⅜-in. steel having an ultimate tensile strength of 58,000 lb. per sq.in. of cross-section, and the weakest part of the boiler is the longitudinal seam with an efficiency of 81 per cent. of the solid plate, what would be the bursting pressure?

M. P. C.

The resistance offered by 1 in. of length of the horizontal seam would be

81% of (⅜ × 1 × 58,000 lb.) = 17,617.5 lb.

As the stress on each inch of length of the joint would be equal to the pressure per sq.in. multiplied by the radius of the boiler, then the limit of resistance would be reached when the pressure per square inch multiplied by the radius equals 17,617.5 lb., i.e., when pressure × 28 = 17,617.5 lb.; therefore, the bursting pressure would be

17,617.5 ÷ 28 = 629.2 lb. per sq.in.

Heat Required to Convert Ice Into Steam—What quantity of heat would be required to convert a block of ice, at a temperature of 18 deg. F., and weighing 10 lb., into steam at an absolute pressure of 30 lb. per sq.in.?

P. N.

The specific heat of ice is 0.504, and to raise a pound of ice from 18 deg. F. to 32 deg. would require (32 — 18) × 0.504 = 7.056 B.t.u. Upon reaching 32 deg. F. each pound of ice would require the addition of 144 B.t.u., called the latent heat of fusion, for conversion of the ice into water at 32 deg. F. For raising a pound of water from 32 deg. F. to the temperature of vaporization at 30 lb. per square inch absolute pressure would require the further addition of 218.8 B.t.u., and for converting the water into steam the additional heat required, called the latent heat of vaporization, would be 945.1 B.t.u. for each pound of water. Therefore, for converting 10 lb. of ice at 18 deg. F. into steam at 30 lb. pressure per square inch absolute would require

(7.056 + 144 + 218.8 + 945.1) × 10 = 13,149.56 B.t.u.

Percentage of Waste from Leaky Blowoff.—In a boiler plant which is operated at 100 lb. gage pressure, what would be the percentage of fuel wasted where the leakage of the blowoff valve amounts to 5 per cent. of the feed water?

R. J.

The percentage would depend upon the temperature of the feed water as well as on the boiler pressure. With steam at 100 lb. boiler pressure each pound of water in the boiler would contain about 309 B.t.u. above 32 deg. F., and each pound of steam would contain about 1188.8 B.t.u. above 32. Assuming the temperature of the feed water to be 150 deg. F., each pound of water wasted would have received

309 — (150 — 32) = 191 B.t.u.,

and each pound of steam would require

1188.8 — (150 — 32) = 1070.8.

As the expenditure of heat realized would be 95 per cent. of 1070.8 = 1017.26 B.t.u. per pound of water fed to the boiler, and the waste of heat per pound of feed water would be 5 per cent. of 191 B.t.u. = 9.55 B.t.u., then

$$\frac{9.55 \times 100}{1017.26 + 9.55} = \frac{93}{100},$$

or practically 1 per cent. of the fuel would be wasted.

Steam Discharged by Safety Valve—What is the formula for determining the amount of steam escaping from a safety valve?

T. T. G.

Napier's rule for the discharge of steam through an unrestricted aperture from one pressure into another of three-fifths or less absolute pressure is

$$w = \frac{A\,P}{70}$$

in which

w = Weight of steam discharged, pounds per sec.;
A = Effective discharge area, square inches;
P = Absolute pressure of steam on the entrance side of the aperture

The rule, therefore, holds true for the discharge of steam to the atmosphere, when the escaping steam is of greater pressure than $^5/_3$ of 14.7, i.e., over 24.5 lb. absolute, or more than

24.5 — 14.7 = 9.8 lb. per sq.in. gage pressure.

According to the formula, the discharge in pounds per hour would be

$$\frac{A\,P}{70} \times 60 \times 60 = 51.4\,P\,A.$$

Allowing for the resistance of the orifice the formula for weight discharged per hour would be

$$W = 51.4\,K\,P\,A$$

The value of K for the standard safety valve orifice has been determined to be about 0.925, so that when the gage pressure is above 10 lb. per sq.in. the formula for the discharge of steam from a safety valve becomes

$$W = 51.4 \times 0.925 \times A \times P = 47.5\,A\,P \text{ lb. per hr}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design—IV

HEATING, VENTILATION AND BOILER POWER

The first step in the design of any heating system is to decide upon the inside temperature it is desired to maintain in the coldest weather. For the Middle West and New England it is customary to assume zero as the minimum outside temperature which is likely to continue for any length of time, and a heating system designed on this basis will usually prove satisfactory. For temporary periods of colder weather, the amount of fresh air may be reduced, and the ventilating equipment be employed solely for heating purposes by circulating inside air. In the case of machine and forge shops, foundries, etc., where the men are more or less actively engaged, a drop of 10 deg. or so from the normal inside temperature will not cause any particular discomfort.

Unless the building is particularly exposed to high winds, or is in a locality where the temperature frequently falls to a lower point, a minimum of zero may be assumed and the heating equipment based on the following inside temperatures under this condition: Offices and drafting room, 70 deg.; paint shop, 80 deg.; machine and pattern shops and carpenter's shop, 60 deg.; foundry and forge shop, 50 deg.; storage for patterns and general supplies, 40 deg.

HEAT LOSSES

The heat loss from a building is due to two principal causes, first, transmission through walls and windows, and second, that due to leakage. Transmission depends chiefly upon the thickness and material of the walls and the difference between the inside and outside temperatures; while leakage is affected more by the tightness of the building construction and the strength of the winds. It is also well to add something to the capacity of the plant, say 10 per cent., for "warming up" when the heat is shut off at night.

There are various tables of heat transmission prepared to cover a wide range of conditions. The following has been abridged from one of these and applies especially to the conditions found in manufacturing plants.

TABLE 1—HEAT LOSS IN B.T.U. PER SQ.FT. PER HR.

Material and Thickness	Diff. Between Inside and Outside Temp., Deg. F. 40	50	60	70
8-in. brick wall	18	22	27	31
12-in. brick wall	13	16	20	23
16-in. brick wall	10	13	16	19
4-in. reinforced concrete	39	45	57	65
8-in. reinforced concrete	23	29	35	40
12-in. reinforced concrete	17	21	26	30
Tar and gravel roof	12	15	18	21
Slate on matched boards	12	15	18	21
Unlined metal	32	40	48	56
Cement floor	6	8	10	12
Single window	50	60	73	85
Single monitor window	56	70	84	98
Single skylight	42	52	63	73

The heat loss by leakage can only be estimated approximately by multiplying the heat loss by factors based on experience, and for average conditions the following may be used:

Exposure to winds	1.12
Leakage with good construction	1.00
Leakage with fair construction	1.10
Leakage with poor construction	1.20
For warming up	1.10

COMPUTATIONS FOR HEAT LOSS

Figs. 1, 2 and 3 are diagrams representing sections through the machine shop, foundry and forge shop, respectively, and give approximate dimensions. In making the computations it is assumed that all dimensions are taken from the architects' drawings, as would be the case in practice, and the work is given for the purpose of illustrating the methods employed. The factors for transmission and leakage are taken from the data given previously, it being assumed that the construction is of the best so that only "exposure to winds" and "warming up" need be provided for when computing the leakage.

Machine Shop—Constructed of reinforced concrete, 12 in. thick for the first story and 8 in. for the second; monitor walls of unlined metal; roof, tar and gravel; floor, cement; and all windows single. The building to be maintained at 60 deg. in zero weather. The heat loss may be computed as follows:

Wall, 12 in. thick	10,000 sq.ft. × 26 =	260,000
Wall, 8 in. thick	8,000 sq.ft. × 35 =	280,000
Wall, monitor	5,000 sq.ft. × 48 =	240,000
Windows, main walls	9,000 sq.ft. × 73 =	657,000
Windows (monitor)	2,500 sq.ft. × 84 =	210,000
Roof	40,000 sq.ft. × 18 =	720,000
Floor	40,000 sq.ft. × 10 =	400,000
Total B.t.u.		2,767,000

Correcting for exposure to winds and warming up, gives

$$2,767,000 \times 1.12 \times 1.10 = 3,408,944 \textit{ B.t.u. per hr.}$$

or in round numbers, 3,409,000 B.t.u.

If special ventilation is provided with zero conditions outside, additional heat will be required for each complete air change per hour. The cubic contents is 1,760,000 cu.ft., and as one heat unit will raise the temperature of 55 cu.ft. of air one degree

$$1,760,000 \times \tfrac{60}{55} = 1,920,000 \textit{ B.t.u.}$$

will be required to raise the temperature of this volume of air through 60 deg. Changing this air twice an hour would require 3,840,000 B.t.u.

Foundry—Walls of reinforced concrete 8 in. thick; all other construction the same as before. The inside temperature will be 50 deg. in zero weather.

Wall, 8 in. thick	7,000 sq.ft. × 29 =	203,000
Wall, monitor	2,000 sq.ft. × 40 =	80,000
Windows, main walls	2,000 sq.ft. × 60 =	120,000
Windows (monitor	1,000 sq.ft. × 70 =	70,000
Roof	15,000 sq.ft. × 15 =	225,000
Floor	15,000 sq.ft. × 8 =	120,000
Total B.t.u		818,000

Correcting for exposure and warming up gives

$$818,000 \times 1.12 \times 1.10 = 1,007,776$$

or practically 1,007,800 B.t.u. per hr.

Ventilation for this building is to consist of four changes of air per hour for a stratum 10 ft. high over the entire floor, which amounts to

$$100 \times 150 \times 10 \times 4 = 600,000 \textit{ cu.ft.}$$

of air per hour and requires

$$600,000 \times \tfrac{50}{55} = 545,454 \textit{ B.t.u.}$$

which we will call 545,000 B.t.u.

Forge Shop—Construction, inside temperature and ventilation the same as for the foundry:

Wall, 8 in. thick	4,000 sq.ft. × 29 =	116,000
Wall, monitor	800 sq.ft. × 40 =	32,000
Windows (main walls)	2,000 sq.ft. × 60 =	120,000
Windows (monitor)	400 sq.ft. × 70 =	28,000
Roof	500 sq.ft. × 15 =	7,500
Floor	500 sq.ft. × 8 =	4,000
Total B.t.u.		307,500

Correcting for exposure and warming up gives

$$307{,}500 \times 1.12 \times 1.10 = 378{,}840 \textit{ B.t.u. per hr.}$$

The air supply for ventilation equals

$$50 \times 100 \times 10 \times 4 = 200{,}000 \textit{ cu.ft. per hr.}$$

requiring

$$200{,}000 \times \tfrac{50}{55} = 181{,}818 \textit{ B.t.u.}$$

or say 181,800 B.t.u.

Offices—Walls of 12-in. concrete; inside temperature 70 deg.; ventilation, six changes per hour.

Wall	1800 sq.ft. ×30 =	54,000
Windows	400 sq.ft. × 85 =	34,000
Total B.t.u.		88,000

Correcting for exposure and warming up gives

$$88{,}000 \times 1.12 \times 1.10 = 108{,}416 \textit{ B.t.u. per hr.}$$

or approximately 108,400 B.t.u. The air supply for ventilation is

$$60 \times 70 \times 16 \times 6 = 403{,}200 \textit{ cu.ft. per hr.}$$

and requires

$$403{,}200 \times \tfrac{70}{55} = 513{,}164 \textit{ B.t.u.}$$

which is approximately 513,200 B.t.u.

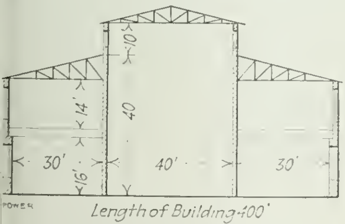


Fig. 1. Machine Shop

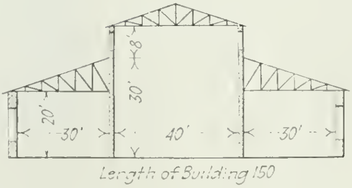


Fig. 2. Foundry

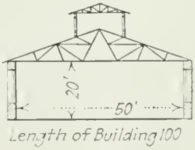


Fig. 3. Forge Shop

Taking up the other rooms to be heated and ventilated, n a similar manner, the following results are obtained:

Tool Room—Temperature, 70 deg., air supply, four hanges per hour.

For heating, 108,240 B.t.u. per hr.; for ventilation, 268,800 cu.ft. per hr., requiring 342,100 B.t.u.

Drafting Room—Temperature, 70 deg., air supply, ix changes per hour. For heating, 112,300 B.t.u. per r.; for ventilation, 378,000 cu.ft. per hr., requiring 481,-00 B.t.u.

Pattern Shop—Temperature, 60 deg.; air supply, four hanges per hour. For heating, 96,300 B.t.u. per hr.; or ventilation, 252,000 cu.ft. per hr., requiring 274,900 .t.u.

Carpenter Shop—Temperature 60 deg.; no special venlation. For heating, 132,800 B.t.u. per hr.

Paint Shop—Temperature, 80 deg.; ventilated from achine-shop system. For heating, 45,000 B.t.u. per hr.

Storage Space—Temperature, 40 deg.; no ventilation. or heating, 330,000 B.t.u. The storage space to be eated includes the pattern storeroom and that adjacent the carpenter shop. The other storehouse is for stock nd is not heated.

The first step in computing the boiler power is to find the total heat units required for both heating and ventilating in zero weather and see how it compares with the heat available in the exhaust steam. In computing the heat requirements two changes of air per hour in the main shop in zero weather, with the idea of increasing this up to three changes as the outside temperature rises, will be assumed. For the other buildings and departments the heat quantities first computed will be taken. These are as follows:

	B.t.u. per Hr.
Machine shop heating	3,409,000
Machine shop ventilation	3,840,000
Foundry heating	1,007,800
Foundry ventilation	545,000
Forge shop heating	378,840
Forge shop ventilation	181,800
Office heating	108,400
Office ventilation	513,200
Tool room heating	108,240
Tool room ventilation	342,100
Drafting room heating	112,300
Drafting room ventilation	481,100
Pattern shop heating	96,300
Pattern shop ventilation	274,900
Carpenter shop heating	132,800
Paint shop heating	45,000
Storehouse heating	330,000
Total	11,906,780

As the exhaust is to be used for heating, and the buildings are somewhat scattered, it will be best to employ a vacuum system with a suction attached to the main return. This will prevent any additional back pressure from being thrown upon the engine and also insure a free return of condensation to the receiving tank without trouble from water-hammer.

With this arrangement we may count on a maximum steam pressure of zero gage, or that of the atmosphere, the latent heat of which is found from a steam table to be 970 B.t.u. With this assumption the total steam requirements for heating and ventilation in zero weather will amount to

$$11{,}906{,}780 \div 970 = 12{,}275 \textit{ lb. per hr.}$$

The steam consumption, or water rate, of an engine varies according to a number of conditions, depending upon the type, size, steam pressure, speed, cutoff, etc., and if possible should be obtained from the makers for the particular machine to be used. If the make has not been decided upon, Table 2 may be used, which gives average values for engines of medium-size, first-class design:

TABLE 2—AVERAGE STEAM CONSUMPTION OF SIMPLE AND COMPOUND ENGINES

Type of Engine	—Lb. Steam per I. Hp.-Hr.— Noncondensing	Condensing
Simple high speed	30 to 34	22 to 26
Simple medium speed	28 to 32	21 to 25
Simple Corliss	26 to 30	20 to 24
Compound high speed	24 to 28	18 to 22
Compound medium speed	23 to 27	17 to 21
Compound Corliss	22 to 26	16 to 20

In the case of the engine selected, compound moderate speed, a water rate of 18 lb. per i.hp.-hr. was assumed. The corresponding rate noncondensing, which would be the condition under which it would operate during the heating season, is found from Table 2 to be 24 lb., the next to the lowest figure being taken in each case on account of the large size of the engine.

The energy in the steam available in the exhaust from an engine will vary from 80 to 90 per cent. of that supplied from the boiler, depending upon the cylinder condensation. Taking an average of 85 per cent. in the present case, the energy, or we may say the pounds of steam available, would be

$$670 \times 24 \times 0.85 = 13{,}668 \textit{ lb. per hr.}$$

which is slightly more than the maximum requirements for heating and ventilation. This means that the boiler power may be computed solely upon the steam requirements for power and lighting and that nothing need be added for heating.

In case of the lighting plant there is a total of 158 i.hp. of compound high-speed engines running at one time. During the heating season, which is practically the only time they will be used, they will run condensing and from Table 2 a water rate of 20 lb. per i.hp.-hr. may be assumed. This will amount to

$$158 \times 20 = 3160 \textit{ lb.}$$

of steam per hour. Adding this to that required by the main engine makes

$$16{,}080 + 3160 = 19{,}240 \textit{ lb.}$$

Steam auxiliaries, such as feed and condenser pumps, will use approximately 5 per cent. of the above, making the total maximum weight of steam to be supplied by the boilers

$$19{,}240 \times 1.05 = 20{,}202 \textit{ lb. per hr.}$$

Assuming a boiler pressure of 120 lb. gage, and a feed-water temperature of 190 deg., the factor for equivalent evaporation from and at 212 deg. is found from a table of such factors to be 1.066, which means that

$$20{,}202 \times 1.066 = 21{,}535 \textit{ lb.}$$

must be evaporated from and at 212 deg. per hour by the boilers. The boiler-horsepower is now easily determined, being

$$21{,}535 \div 34.5 = 624$$

a normal rating of 600 hp. would be sufficient.

NUMBER AND SIZE OF BOILERS

The type of boiler to be used will depend somewhat upon local conditions and the preference of the owners.

Experience has shown that when boilers of any of the well known types are equally well designed and proportioned for the work to be done, are operated with the same skill and provided with the same quality of fuel, there will be very little difference in operating economy.

The water-tube boiler has the advantage of greater safety and requires less space, and for these reasons is more frequently employed in office buildings and institutions. In the present case, either water-tube or fire-tube boilers should give satisfaction, but for purposes of illustration, we will use the horizontal fire-tube boiler.

Dividing the total power into five units calls for 120 hp. each. In plants of large size a spare boiler should always be provided for cutting in in case of repairs or cleaning, bringing the number in the present case up to six. Based on 12 sq.ft. of heating surface per horsepower, they should be 72 in. in diameter and contain ninety-eight $3\frac{1}{2}$-in. tubes, 16 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Uncle Tom Edison, our well known and respected inventor, has recently appeared in print quite some. We have followed his utterances with interest until now. Now, "Mr. Edison says we are too rich." Bet this is his very latest invention.

⁂

Instead of worrying about turkey for Thanksgiving it looks as though us engineers had reason for thanksgiving that Turkey is no nearer.

⁂

John J. Bjoblie has invented a headlight to be coupled with the automobile's steering gear so that it may be automatically shifted with the movement of the front wheel. You'd think that Beejay would have first directed his inventiveness toward improving the articulate mechanism of his name. 'Spose the papers spell it correctly?

⁂

With those who go down to the sea in ships, who have fought their way to the uttermost ends of the earth, enduring privation and meeting death—with these heroes and martyrs to the glory of discovery is the marine engineer! Of the nine men recently rescued in the Arctic, two were engineers and one a fireman. And they and their like would go back tomorrow.

⁂

"Women must end all war!" is the latest dictum of the suffragists. When you go home from the plant tonight, yo and the missis might "discuss" this topic—you know best It needs solution. Arnica is a good solution, but— Say, p'r'ap you hadn't better start anything.

⁂

Following the Roentgen rays comes Ulivi's rays. Toddling along down the alphabet, somebody will soon be discovering the "H raise." Mebbe this somebody is one of the nine gods of war.

⁂

That veteran electrical engineer, C. O. Mailloux, recentl put up a strong defense for the isolated plant at the recen meeting of the A. I. E. E. He believes, as we do, that bot services have their particular place, but that there are man places where one is better than the other.

⁂

Who says the churches are losing their drawing power Not in Brooklyn. Two crooks drew out the poor-box money a cop drew his revolver and the black maria drew the whol bunch to the judge, who drew up a scheme to tuck 'em awa for two years. Some drawing.

⁂

Doctor Humphreys, of Stevens Institute, recently wrote a excellent prescription for sick public-service commissions "Compose them of common-sense men, broadly trained, broad minded, fair, and competent as investigators (an unusua qualification); and in each commission there should be me fully qualified in the theory and practice of the profession of engineering, law, business, finance and accountancy."

⁂

The London "Lancet" says that smoking in moderatio "does much to allay the restlessness and muscular irritability engendered by mental and physical fatigue." It quote Huxley, who was some pumpkins along the thinking line, a in favor of it. If you can't smoke you might show this to th boss—but first find out if he knows whether Huxley is th said pumpkin, or just a new variety of chewing gum.

⁂

Twenty-six states now have compensation acts, and "the have done more than any other thing to bring about earnes efforts for the prevention of industrial accidents." Reduced to dollars and cents, anything that mutually affects th employer's cash drawer and the employee's envelope usuall gets a fair tryout.

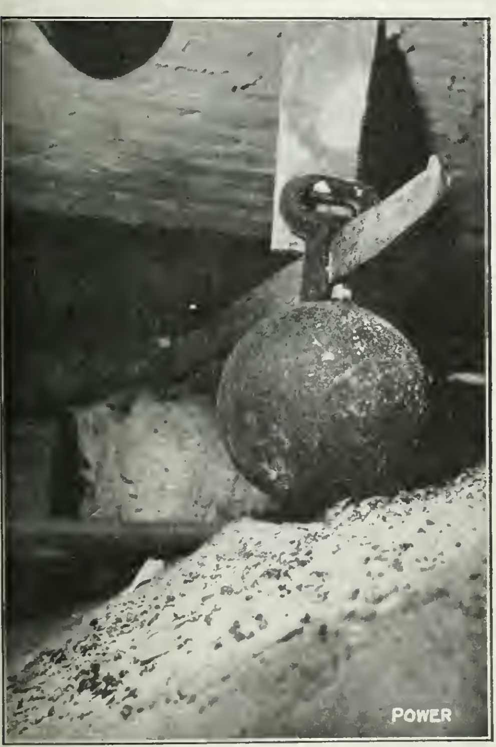
⁂

In Wisconsin, for instance, for the past 28 months nearl $600,000 has been paid to workingmen or their dependents i 6894 cases. Only 154 cases had to be decided by the Industria Commission. All the others were settled amicably. Hoora for the better understanding!

Boiler Explodes under Sidewalk

Shortly after nine o'clock, Oct. 27, a 250-hp. double-furnace dry-back, Scotch marine type boiler exploded at the Continental Hotel, Forty-first St. and Broadway, New York City, causing the death of two men and the serious injury of two others. The boiler was one of a pair used in connection with the hotel heating and electric plant.

The conditions previous to the accident were as follows: The tubes, of which there were 108, had caused considerable trouble and it was decided to retube both boilers. The work on the one which failed had been completed; it had been given a hydrostatic test of 188 lb. and was passed by the inspectors for the police department and the Hartford Steam Boiler Inspection & Insurance Co. A steam pressure of 125 lb. was allowed. The boiler was put in service on Oct. 18, just ten days previous to the accident.



Lever Held Down by Board

The immediate cause of the explosion was a bulging outward of the rear tube sheet, which pulled entirely away from the tubes in the central area where the bulging was naturally greatest. All the tubes showed signs of some movement The new tubes had not been beaded over and, therefore, supported the tube sheet only by the friction of the metal. The staying effect was further reduced on account of the tubes being considerably under size and shims had to be used around them to fit the holes in the tube sheet. There was no stay rod (or socalled stay tube) in the tube area. The boiler was not equipped with a fusible plug.

A representative of "Power" visited the plant and was present when Lieutenant Van Keuren, in charge of the boiler squad, with his inspectors and one from the Hartford company, made their inspection and had their attention called to the discovery previously made by one of the police inspectors of a gag on the safety valve. This was a board 12 to 14 in. long wedged endwise between the lever of the safety valve and the brick arch which forms the ceiling of the boiler room and base for the sidewalk. With this prop in position it would be impossible for the valve to operate and relieve the boiler in case of over-pressure, as it had been cut and used for the purpose of holding the valve closed against the hydrostatic pressure during the test referred to, and there was no locked pop valve attached to the boiler.

The chief engineer disclaimed any knowledge of when the prop might have been put there, but stated under oath that he himself had removed it and laid it on the top of the boiler after the inspection test was over. He further said that on Thursday the pressure had caused the safety valve to operate, substantiating his statement that the gag had been removed after the test and must have been replaced subsequently by some one unknown to him.

It is surprising that such conditions could exist under the close supervision of the inspectors of the insurance company carrying the risk. Later, the chief engineer and the night engineer (who is in a hospital in a serious condition) were put under arrest charged with homicide, and a warrant is out for a third man.

Exhibits from Europe Reach San Francisco

On Sept. 24 Secretary of State Bryan announced that no foreign country had withdrawn from its participation in the Panama-Pacific International Exposition.

Since then many large consignments of costly exhibits from European and other countries have reached San Francisco and chartered steamers will soon leave with great loads of exhibits for that city. In view of the apprehension for the success of the fair since the outbreak of hostilities in Europe the following items have been selected from a statement just issued by the exposition authorities, because they relate to the participation of the affected countries:

Many European nations, associations of exhibitors, and individual exhibitors will be represented at the exposition and there will be many important entries from Europe in the various events. Several of the European nations have increased their funds for participation since the outbreak of the war; others have made appropriations contemplated but not ratified before the commencement of the conflict.

In addition, an unprecedented number of selective exhibits will be shown from South America, the United States, Canada and the Oriental countries, the plans for exhibition having been greatly amplified during the past six weeks.

During the week ending Oct. 11 the first shipment of exhibits reached San Francisco from Holland. Shipments of exhibits during the week were received from Luxemburg, Ireland and France. A large consignment of exhibits from London was installed in the Palace of Mines. Five carloads of social economy exhibits, made under the supervision of Dr. Philip Rauer of Stuttgart, have reached the city. More than five hundred tons of exhibits and materials for the Japanese displays and pavilions are leaving Japan in two shipments, one of which is scheduled to arrive within a few days.

The construction of the exposition is far advanced. The main exhibit section is completed; the installation of the works of famous sculptors, embracing more than eight hundred different pieces and groups of statuary, is 75 per cent. completed; the landscaping of the exposition grounds and courts is 82 per cent. completed; hundreds of thousands of acacias, rhododendrons, tree ferns, orange trees, dato palms, rare shrubs and ornamental plants, brought from the far corners of the world, are now thriving in their new environment.

Work has progressed well upon the "Zone," the amusement section, which gives evidence of its high educational character and great intrinsic worth; an outlay of $10,000,000 will be made in this section when completed and more than seven thousand persons will be employed there during the exposition.

In the section devoted to the pavilions of the nations and the buildings of the American states many of the edifices are finished and others are rapidly nearing completion.

The German Kali Syndicate Building, constructed in part by the German government, is more than half finished and will be rushed to completion. The exposition headquarters in Berlin, established by important German industries, received applications for exhibit space from leading German firms two months after the outbreak of the war.

The government of the Netherlands has increased its appropriation by an additional $300,000.

Since war was declared Italy has formally ratified the appropriation of $400,000 for the Italian national display.

Commissioner J. Heyerdahl-Hansen, of Norway, who recently arrived in San Francisco, brought official notice of Norway's determination to carry through its plan for participation regardless of the state of war.

A comprehensive exhibit of roses and bulbs is now ready in Belgium for shipment.

France sent word within a few weeks after the declaration of war that there would be no change in her plans and entries were received in the live stock, horticultural and other departments during the latter part of September and subsequently.

Representatives of British exhibitors arrived in San Francisco as early as August to inaugurate the plans for presenting their exhibits and subsequent shipments of exhibits have reached that city.

The Japanese government made an original application for 144,000 square feet of exhibit space in all of the exhibit palaces. Commissioner Ishii, after the outbreak of the war, arranged for an additional space of 21,419 square feet in the Palaces of Food Products, Manufactures and Horticulture. The Japanese Commission reports that the most representative displays of Japan have been gathered from every portion of the Empire

France and England are sending rare varieties of hot house plants and Japan will add a collection of lilies to the horticultural display in the palace.

Entries in the livestock department have been received since the outbreak of the war from Brittany and Boulogne, France.

The Grand Duchy of Luxemburg, despite the war, has prepared and shipped an exhibit to compete for the $1000 prize offered for the most perfect variety of rose originated for and exhibited at the exposition.

ENGINEERING AFFAIRS

Training Class for Trade Teaching—During 1913 and 1914, Pratt Institute, Brooklyn, N. Y., tried the experiment of having a training class for teachers of the different trades in industrial schools. This class consisted of 17 men, between the ages of 24 and 40, who were working at various trades during the day and were brought together in an evening class to receive instruction in the principles of teaching as applied to the industrial school. The class met three times a week for 24 weeks, each session being two hours long. The instruction did not include shop-work practice or related trade subjects, but was confined to the principles of trade teaching.

The training given consisted of two parts: Practice teaching in the New York evening trade schools one evening each week. (The majority of the class taught two evenings a week, the second evening being optional.) Class work at Pratt Institute two evenings each week. The latter was divided into two parts: Demonstration work in the form of practice teaching before the class, and conference and lecture work, consisting of discussions, readings and occasional lectures upon such subjects as:

The organization and equipment of the trade school shop.
Analyzing a trade for the purposes of instruction.
The commercial product.
The project scheme.
The teaching of "related work."
Basis of the course of study.
The organization of the industrial school.
How to handle the industrial school boy.
The qualifications of the industrial school teacher.
Types of schools—their organization and function.
What is education?
The difference between vocational education and general education.
The difference between vocational education on the one hand and prevocational education, practical arts and manual training on the other.

This course will be continued next year on essentially the same plan and information for prospective students can be secured by addressing the institute.

PERSONALS

C. M. Ripley, formerly with Pattison Bros., consulting engineers, is now with the Richard D. Kimball Co., consulting engineers, New York City.

George W. Stevenson, formerly master mechanic at Thomas A. Edison's Silver Lake chemical plant, Newark, N. J., has accepted a position as master mechanic with the Empire Steel & Iron Co., Oxford, N. J.

L. B. Lucas, Toronto, Ohio, has been appointed a member of the Hydro-Electric Power Commission of Ontario, replacing Hon. J. S. Hendrie, who has been appointed Lieutenant-Governor of the Province of Ontario.

F. C. Herrman has resigned as chief engineer of the Spring Valley Water Co., San Francisco, Calif., and will engage in engineering practice, specializing in water supply, irrigation, drainage, sanitation and valuation, with offices in the Merchants' Exchange Building, in San Francisco.

BUSINESS ITEMS

Mr. Robt. E. Mullane has been elected president of the D. T. Williams Valve Co., Cincinnati, Ohio, succeeding Mr. D. T. Williams, who recently resigned.

The Flanner Water Tube Boiler Co. has moved its business to Akron, Ohio. A Chicago office will be opened at 1651 Marquette Building, with Mr. A. H. Chas. Dalley in charge.

The Wm. Powell Co., Cincinnati, Ohio, has recently issued the Powell Whistle Booklet which gives the complete story of Powell steam whistles and whistle valves. A copy is sent to anyone on request.

The Smooth-On Mfg. Co., Jersey City, N. J., is sending out a circular showing how the Drake Cake Bakery in Brooklyn used Smooth-On Iron Cement No. 7 for waterproofing, dust proofing and hardening concrete.

In order to keep in closer touch with its customers the Uehling Instrument Co. has discontinued its selling connection with the Uehling Sales Co. All future transactions will be handled by the main office in Passaic, New Jersey.

An interesting bulletin sent out by the Yarnall-Waring Co. Chestnut Hill, Philadelphia, Penn., shows a record of 997 Simplex "Seatless" Blow-Off Valves sold to a total of only 35 concerns, giving an idea of large blow-off installations this company is making.

The Duquesne Light Co., Pittsburgh, Penn., has placed an order with the Yarnall Waring Co., Mermaid Ave., Chestnut Hill, Philadelphia, Penn., for two 300,000 lb. per hour "Lea" V-Notch Recording Liquid Meters for the measurement of condensate in their Brunats Island Power Plant. They had previously installed three meters of the same capacity.

The Builders Iron Foundry, Providence, R. I., is getting out a new Hot Water Bulletin No. 85. It is a brief but comprehensive pamphlet on the Venturi Hot Water Meter, giving a short history of the meter, the explanation of the principle involved, the different types of instruments, their methods of installation, and several calibration tests. Also shows a number of interesting installations. Sent on request.

The B. F. Goodrich Co., Akron, Ohio, recently made a shipment of 18 tons of Longlife belting in response to one cable order from abroad. In this connection it is interesting to note that this company turns out five miles of belt a day, has fifteen miles of belt in process of manufacture and has about fifty miles of belting under orders. 15,000 persons are employed in the Goodrich plant.

"Westinghouse Electric Motors for Machine Tool Service" is the title of an exceedingly comprehensive pamphlet, with an art cover, which has been issued by the Westinghouse Electric & Mfg. Co. This book, which is profusely illustrated, describes the electrification of a machine shop, going into some detail as to the type of motor to be selected for each machine, and a recital of the characteristics of direct and alternating-current motors as applied to this work.

The Westinghouse Electric & Mfg. Co. has just issued Leaflet No. 3749, covering Westinghouse Synchronous Booster Rotary Converters, in which this type of apparatus is very fully described and illustrated. The advantages of this type of machine are given together with a detailed account of its method of operation and construction details. A cross section view also gives a clearer understanding of its construction. A number of installation views are also shown.

The National Transit Co. Oil City, Penn. is building four horizontal duplex compound outside center packed plunger oil pumps for the Panama Canal Terminal Pumping Stations. There will be a pumping station at the Atlantic and at the Pacific Terminal of the Canal and two of the above pumps are to go in each station for pumping fuel oil to and from the oil ships and the oil tanks on shore. Cosden & Co., producers and refiners in high-grade petroleum, have recently purchased from the National Transit Co. two 100-hp. horizontal twin gas engines, each direct connected to a vertical triplex single-acting power pump.

The Bruce Macbeth Engine Co., Cleveland, Ohio, has recently installed the Meriam Steam Process of generating low pressure steam by means of gas engines for the Microscope Co., Cleveland; Steffan Shoe Co., Buffalo, N. Y.; Strootman Shoe Co., Buffalo, N. Y.; C. W. Downey (garage), Cleveland; J. P. Eustis Mfg. Co., Cambridge, Mass.; Detroit City Gas Co., Detroit, Mich.; Wellington Milling Co., Wellington, Ohio; The Ohio State Reformatory, Mansfield, Ohio; Chisholm Steel Shovel Works, Cleveland; Consumers' Ice & Cold Storage Co., Lexington, Ky.; American Glove Co., Dunkirk, N. Y.; Younglove Building, Cleveland; Wood & Spencer Co., Cleveland; Northside Cameraphone Building, Pittsburgh; U. S. Paper Goods Co., Cincinnati, Ohio; Swarthmore College, Swarthmore, Penn.; Cleveland Steel Barrel Co., Cleveland; Fessenden Light & Power Co., Fessenden, North Dakota.

NEW EQUIPMENT

CENTRAL STATES

The Willard Storage Battery Co., Cleveland, Ohio, will construct a power house, estimated to cost $5000.

It is reported that the Fairbanks-Morse Mfg. Co., Beloit, Wis., will remodel its power house preparatory to installing new boilers in the early spring.

Frank H. Josslyn and LeRoy Herrod, Oshkosh, Wis., according to press reports, have purchased the Weyauwega

POWER

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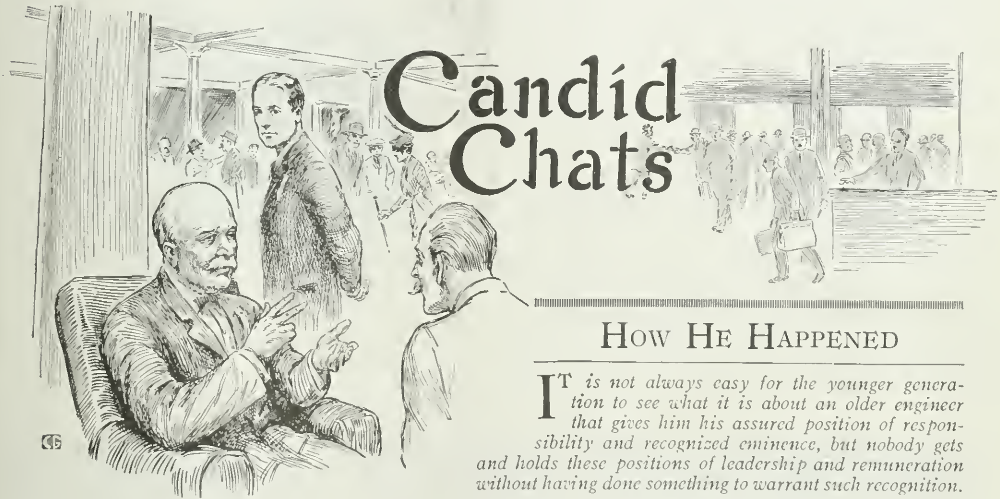


Candid Chats

HOW HE HAPPENED

It is not always easy for the younger generation to see what it is about an older engineer that gives him his assured position of responsibility and recognized eminence, but nobody gets and holds these positions of leadership and remuneration without having done something to warrant such recognition.

One of these veteran engineers was present at a recent convention. We knew him when he was winning his spurs. He had already made a hit by saving money in the power plant of a large textile mill, and was asked to undertake to do it for another with the distinct understanding that there was no money available for improvements. The cost of operating the steam plant for the six months preceding his taking charge of it was upwards of $36,000, as given in the first column of the accompanying table, and they made 812,363 pounds of cotton cloth, besides running four woolen mills and furnishing steam for the dyehouse. Based upon the cotton cloth alone, this would give a cost of power plant operation per pound of cloth of 4.47 cents. For the first six months of his management the cost for the same items fell to $25,544, as shown by the second column, and this notwithstanding an increase of over fifty per cent. in the amount of cloth produced. This brought the operating cost of the power down to 2.06 cents per pound of cloth produced. There was a rise the next year to 2.21 cents, which was still, however, less than half of the cost per pound before he took hold, and on the third six months of his stay he reduced it to 1.69 cents.

Items	6 mo. ending Dec 31, 1882	6 mo. ending June 30, 1883	6 mo. ending Dec 31, 1883	6 mo. ending June 30, 1884
Grate coal	$27,969 15	$11,301 40	$859 10	
Pea coal		8,662 50	10,107 00	$14,791 50
Culm			10,316 00	2,208 00
Wood	1,340 00	136.00	81 00	76 00
Oil and grease	118 15	269 25	414 50	274 00
Pay roll	6,600 00	5,175 17	5,705 94	5,015 96
Total	$36,327.30	$25,544 62	$27,186.54	$22,365 46
Cloth woven, lb	812,363	1,235,784	1,241,763	1,325,712
C per lb	4 47	2 06	2 21	1 69

If the operating cost of the power plant had been the same per pound during the first half of 1884 as it was before he came it would have cost nearly $37,000 more than it did cost to run the plant. Of course, the greater production made for a lower cost per pound, but he actually ran the plant with the expenditure of about $14,000 less money and made 1.63 times as much cloth with it.

For this achievement he received the first year the munificent salary of $2000; but he made good. Other and larger plants offered larger opportunities and he went to them, and did what was expected of him. That is why he is a leading engineer now. There are plenty of plants today where savings of this sort can be made.

There are plenty of men who could make such savings if they were given a free hand.

More confidence in the engineer on the part of the employer and more confidence in himself on the part of the engineer are what is needed to bring the man and the opportunity together.

Draft and Stoker Control at Waterside

By Charles H. Bromley

SYNOPSIS—Describes the means for controlling the draft under the fire and the stoker speed at the Waterside Stations of the New York Edison Co. Also illustrates the stoker-control system in the 201st St. Station of the United Electric Light & Power Co., New York City.

In Waterside Station No. 2, the 650-horsepower water-tube boilers are arranged back to back in two rows, six boilers to a row, the main flue being between the rows. Underfeed stokers are used and the draft is furnished by engine-driven blowers pumping air into a main duct below the boiler-room floor. At each end of this duct is a blower designed for 60,000 cu.ft. of air per min. against a head of 2 in., the blowers being originally used for the hand-fired furnaces before the stokers were installed. These blowers or fans are now run faster to increase both the pressure and capacity demanded by the draft required for the underfeed stokers and higher boiler capacity.

For controlling the air pressure in the duct, and consequently the draft under the fires, a multiple-diaphragm regulating valve governs the speed of each fan engine. Before investigating the details of the diaphragm valve, it is best to understand the air connections between the fan engines and the ducts. The diagram, Fig. 1, shows that at the middle of the main air duct a 1-in. pipe enters. To this short 1-in. piece, a 2-in. cross tee is connected and from one side and bottom of the latter, 1-in. pipe connects to the bottom of each diaphragm. The top of the cross tee contains a length of 2-in. pipe going directly through the floor to an alley between Nos. 3 and 4 boilers, the end of the pipe having a 2-in. valve opening to the atmosphere. This 2-in. pipe rises about four feet above the floor, so that the valve is most conveniently reached.

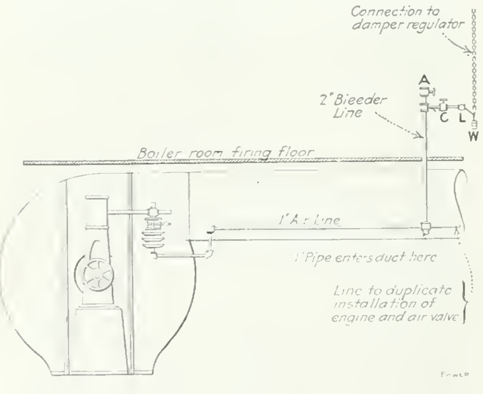

Connection to damper regulator
A
2" Bleeder Line
C
L
W
Boiler room firing floor
1" Air line
1" Pipe enters duct here
Line to duplicate installation of engine and air valve
Power

Fig. 1. Connections to Diaphragm for Regulating Pressure in Air Duct for Underfeed Stokers

The diaphragm regulator is simply a balanced valve actuated by the diaphragms, which in turn are moved by the air pressure from the duct. As the pressure on the diaphragm is very little compared to that necessary to move the valves controlling each of the engines, there must be considerable diaphragm area, especially if the valve is to be sensitive. Therefore, six diaphragms, having a total area of 70 sq.in., are used. A lever and ball for adjusting the valve for minimum pressure are provided.

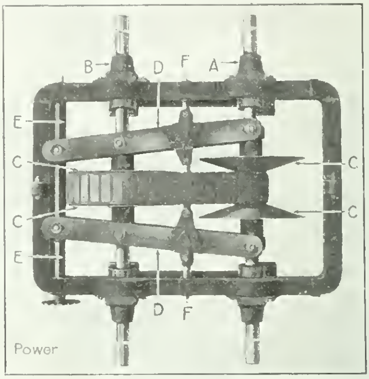


Fig. 2. Transmission Device for Driving Stoker Line Shaft at Variable Speed

As the valve is actuated by the pressure in the air duct, it is evident that various pressures within the capacity of the fan may be carried in the duct by simply allowing a greater or lesser amount of air to escape through the globe valve *A*. The draft over the fires in any unit of six boilers is regulated by using the large baffle of the cinder arrester, the baffle extending the entire length of the flue. This baffle is moved by hand and performs the same function in this respect that individual back or uptake dampers or main dampers do. The CO_2 is higher ordinarily when the draft over the fire is maintained at about 0.05 in. of water, indicated by a U-tube on the control board, Fig. 3.

For automatically regulating the air-duct pressure between two given points, the latter being adjustable, an auxiliary bleeder valve *C* may be used, although this is not the case at Waterside. Besides the auxiliary valve *C*, a lever cock operated by a damper regulator is provided; the cock discharges to the atmosphere.

Suppose it were desired to carry ½-in. pressure in the air duct or under the fire, but to vary the pressure between one-half and three-quarter inches. The valve *A* would be opened to give the ½ in., and the auxiliary bleeder *C* would be opened to give the extra ¼ in. The exit for the air from the auxiliary bleeder is controlled by the movement of the lever cock which is actuated by the damper regulator.

Stoker Control

This method of air control is all the more useful because of the ease with which the stoker speed may be regulated, for both controls are separate and independent. Each unit of six stokers is engine-driven through a variable-speed transmission between the engine shaft and the stoker line shaft, the latter, of course, being driven directly by the variable-speed transmission, shown in Fig. 2. The transmission consists of spline-mounted cone-shaped disks *C* acting as pulleys over which a V-belt runs. Each half of each pulley may be separated from its partner half by the movement of the levers *D* which are pivoted, the levers being operated by a screw *E*, with right- and left-hand threads, so that as the halves of one pulley move inward or toward each other, the halves of the other move away from each other in the same ratio. As seen, this amounts to varying the size of the pulleys, but it insures uniform belt tension for all speeds. To adjust the tension of the belt when this becomes necessary, take-up screws *F* are provided to allow the levers to move inward, thus adjusting the pulleys to the length of the belt. The regulating screw *E* is operated by a chain and sprockets, one of the latter being placed within arm's length of the bleeder valve for the draft system. The driver shaft is designated *A* and the driven *B*.

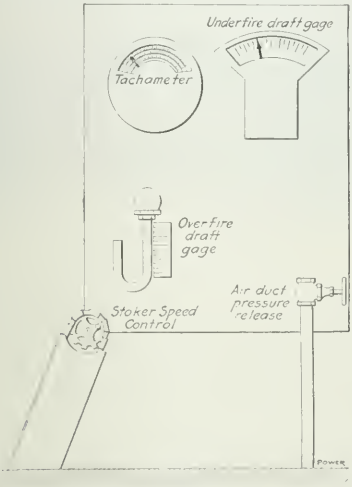


Fig. 3. Diagram of Combustion Control Board

The transmission is made in six sizes. Where about 3500 to 4000 boiler-horsepower (rated) in stokers could be driven from one line shaft, the No. 5 transmission, good for a maximum of 25 hp., would do. This size machine installed costs about $275 or $11 per horsepower. The costs will, of course, increase slightly for machines of smaller powers.

The Control Board

In an alley between boilers Nos. 3 and 4, a control board shown diagrammatically in Fig. 3 is placed. This board has an electrical tachometer with three scales, one calibrated for air pressure, one for pounds of coal per hour, and one for indicating the stoker speed, a pointer-indicating gage to show the draft under the fire and a U-tube gage to indicate the draft over the fire. As shown, the stoker-speed regulator and air-pressure bleeder valves are near the board. At one end of the firing aisle, between two units of six boilers each, are two large steam-flow meters, one for each unit of six boilers.

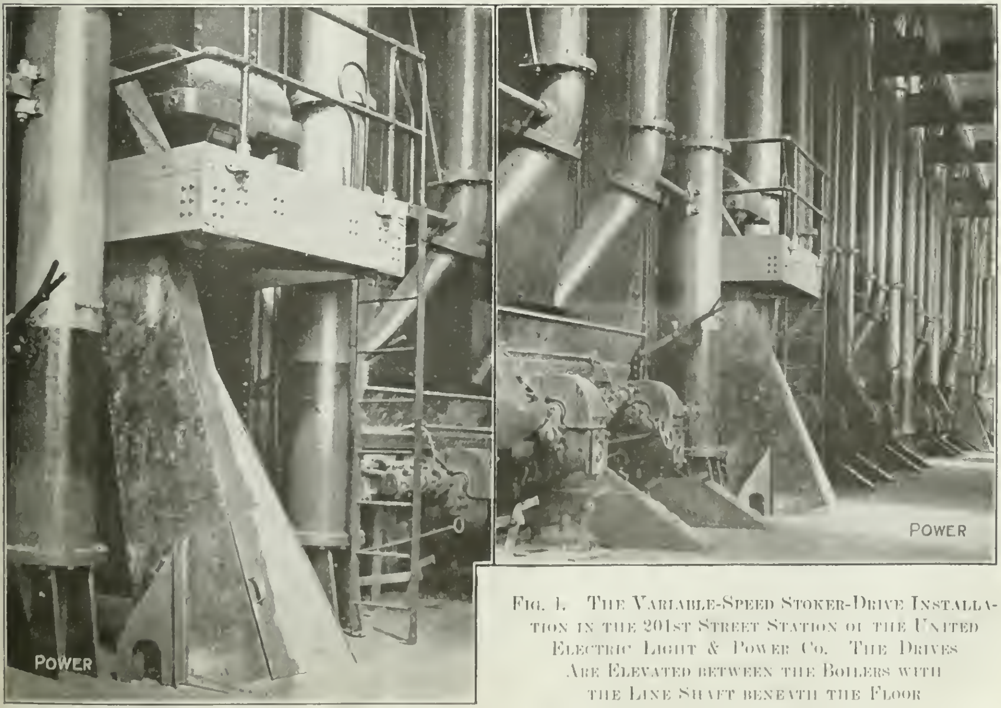


Fig. 4. The Variable-Speed Stoker-Drive Installation in the 201st Street Station of the United Electric Light & Power Co. The Drives Are Elevated between the Boilers with the Line Shaft beneath the Floor

It is seen that with these provisions the fireman knows how much the output of each unit is, how it compares with the other units on the line, and, when more or less capacity is needed, he may have it by a simple, quickly and easily made operation. Fig. 4 shows the same kind of variable-speed stoker drive for the stokers in the 201st St. Station of the United Electric Light & Power Co., New York City. As shown in both Figs. 4 and 5, the stoker line shaft is immediately below the floor while the drive is elevated between two boilers and is motor driven. The speed-regulating sprocket wheel is within convenient reach of the fireman. At Waterside the transmission device is below the boiler-room floor as shown in Fig. 6.

The variable-speed drive for the stoker is the product of the Reeves Pulley Co., Columbus, Ind.; the diaphragm draft control installation was made by the Pitts & Kitts Manufacturing & Supply Co., New York City. A Precision Instrument Co.'s draft gage is used, and the stoker speed is indicated by a Hopkins electrical tachometer.

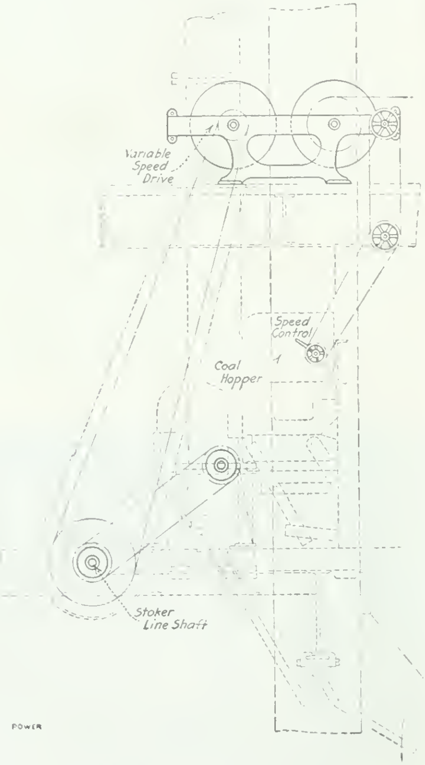


Fig. 5. Diagrammatic Layout of the Stoker Drive at 201st St.

In an effort to eliminate as much as possible the human element in governing combustion, the tachometer is so adjusted that it and the underfire draft gage will read alike when combustion is best. So, as far as the fireman is concerned, all he has to do is to manipulate the stoker-speed regulator and the air-bleeder valve until they register alike and the steam-flow meter shows the unit to be doing its share of steam making. As several varieties of coal with varying characteristics are used in the Waterside stations, it becomes necessary to adjust the tachometer for the varying coal conditions.

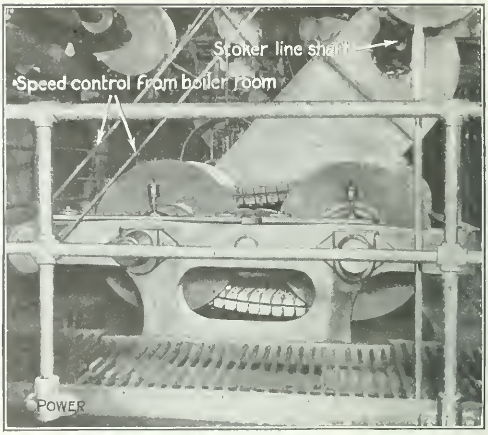


Fig. 6. The Transmission Device below the Boiler-Room Floor at Waterside

Fig. 7 shows the diaphragm valve.

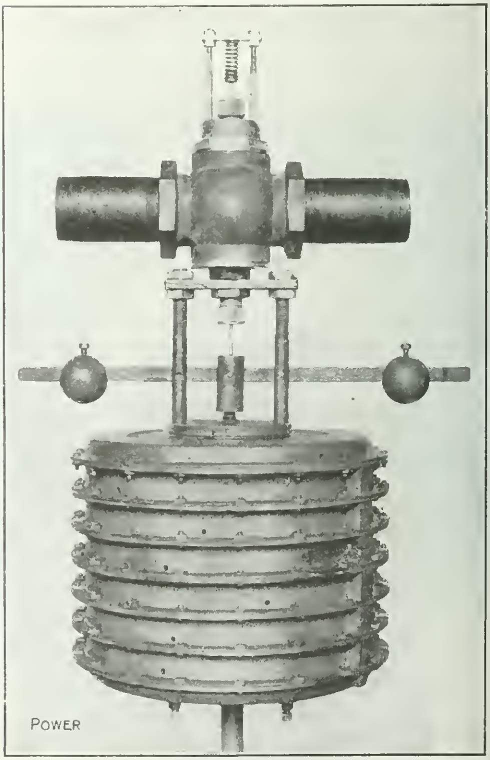


Fig. 7. The Diaphragm Regulating Valve

The First Stumpf Una-Flow Engine Built in America

SYNOPSIS—The first una-flow engine built in America with the coöperation and approval of Professor Stumpf uses only 12.5 lb. of steam per i.hp.-hr. condensing and 16.8 noncondensing, the minimum consumption being at one-half load in both cases. It is only 15x16 in., runs at 250 r.p.m., and is designed to carry 100 kw. at rating.

⁂

A number of engines have been built in America upon the una-flow principle, but the first to be built with the consent and approval of Professor Stumpf, under his patents and designed by the engineers of his representative, the Stumpf Una-Flow Engine Co., who know his standards and methods, is that built by the Ames Iron Works, of Oswego, N. Y., and illustrated herewith.

This engine consists of a 15x16-in. cylinder mounted upon a standard heavy-duty frame. About as many expansions are attainable with the una-flow in a single cylinder without excessive cylinder condensation as are practicable in the two cylinders of a compound, but on account of the absence of loss between cylinders, etc., the una-flow cylinder may be made about 20 per cent. smaller than the low-pressure cylinder of an equivalent compound without loss of efficiency. The full boiler pressure acts upon the large piston, necessitating attention to the large initial stress.

The engine is pleasingly simple in appearance, as will be recognized from Fig. 1; and its internal arrangement and construction are just as simple. Fig. 3 shows a longitudinal and cross-section through the cylinder. Steam enters by the poppet valve in the head, is cut off early in the stroke even at full load, and exhausts through the ports in the middle of the cylinder, when they are opened by the piston passing over them. The piston is shorter than the stroke only by the width of the exhaust port. If, for instance, the piston were $\frac{9}{10}$ as long as the stroke and the port $\frac{1}{10}$, release would take place when the stroke was $\frac{9}{10}$ completed and compression would commence when the piston had proceeded $\frac{1}{10}$ of the way on its backward stroke. If, when the piston covers the exhaust port on the backward stroke, the pressure in the cylinder is low, as when the engine is exhausting into a condenser, the compression, even with a moderate clearance, would

TESTS MADE WITH A 15x16-INCH STUMPF UNA-FLOW ENGINE

	Oct. 5, 1914				June 6, 1914					Sept. 5, 1914					
	—Noncondensing—Saturated—				—Noncondensing—Superheated—					—Condensing—Superheated—					
Test no...	I	II	III	IV	I	II	III	IV	V	I	II	III	IV	V	VI
Load...... ...	¼	½	¾	full	Friction	¼	½	¾	0.85	Friction	¼	½	¾	Full	1½
Steam pressure, lb. per sq in	146	145	145	146	138	140	140	140	137	147	145	145	145	140	140
Speed, r.p.m...	257	256	255	254	262	258	255	253	252	..	..	255	...	..	..
Superheat, deg. F...	...	...	...	...	132	117	130	118	114	50	96	88	93	103	140
Vacuum, in..... .	...	...	...	...	...	...	..	..	...	26	26	25½	25½	25	24
Load on generator, Amperes	100	200	300	400	...	100	200	300	350	...	100	200	300	400	600
Load on generator, Volts..	250	250	250	250	..	250	250	250	250	..	250	250	250	250	250
Indicated horsepower, hp...	55.5	93.4	130.8	171.7	12.9	56.3	92.5	134	152.3	11.5	53	93	131	175.5	257
Steam consumption, lb. i. hp.-hr..	21.0	20.4	20.8	21.3	18.0	17.3	16.8	17.0	17.3	15.0	13.2	12.5	12.5	12.9	15.3

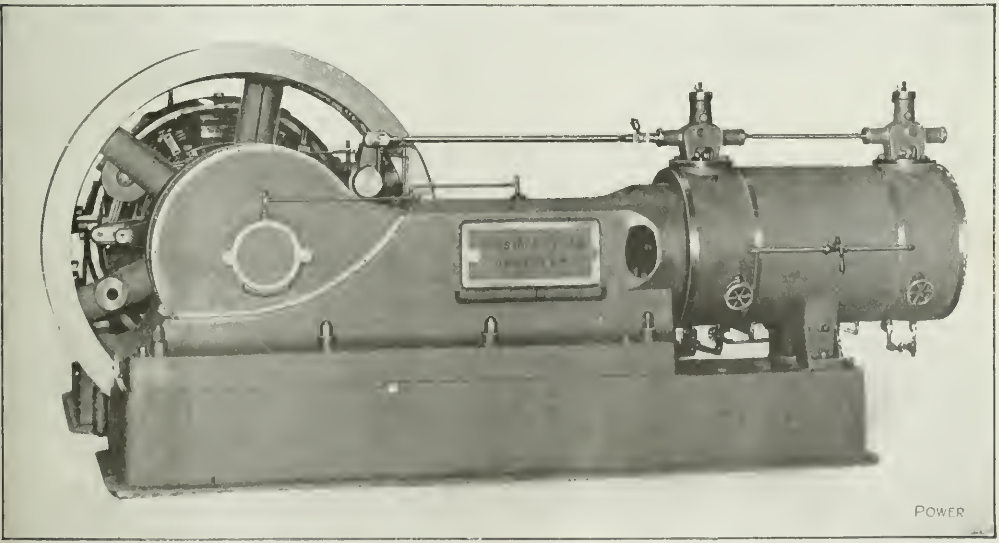


Fig. 1. The First Stumpf Una-Flow Engine Built in America

not be very high. With the exhaust ceasing at $\frac{1}{10}$ of the return stroke there would be $\frac{9}{10}$ of the cylinderful of steam to be compressed into the clearance.

Suppose this to be at the pressure of 2 lb. absolute, about 26 in. of vacuum, and suppose the clearance to be 5 per cent., we have, assuming the pressure to vary inversely as the volume,

$$\frac{2 \times 0.95}{0.05} = 38 \textit{ lb.}$$

showing that even with this early closure the compression would run up to only a moderate amount. If, however, the pressure at the instant that compression commenced were that of the atmosphere, say 15 lb. absolute, there would be with the same clearance

$$\frac{15 \times 0.95}{0.05} = 285 \textit{ lb.}$$

On account of the absence of the usual exhaust port it is possible to keep the clearance very low, it being only 3.1 per cent. in this engine even with its short stroke. For a noncondensing engine it is necessary, however, to have a greater clearance volume when the closure of the exhaust is thus early in the stroke. Professor Stumpf argues that the harmful effect of clearance, due to its volume, is slight compared with that due to its surface, and

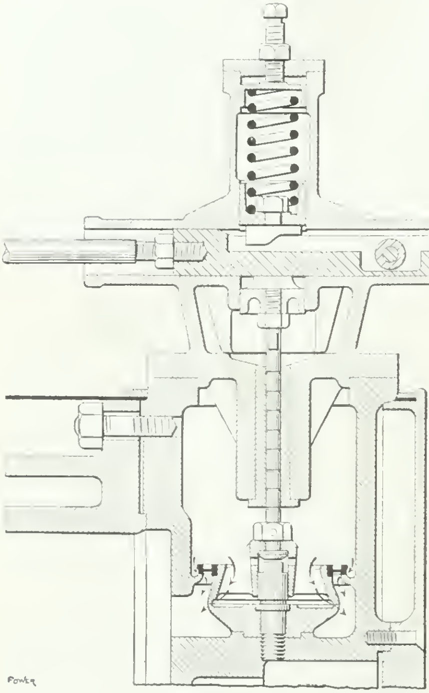


Fig. 2. Admission Valve and Gear

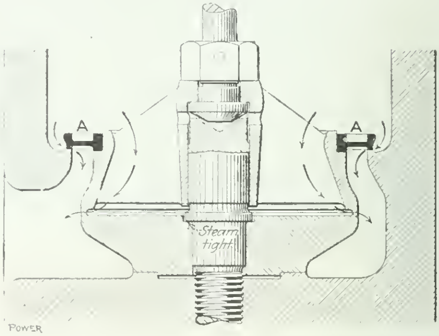


Fig. 1. Double-Beat Poppet Admission Valve

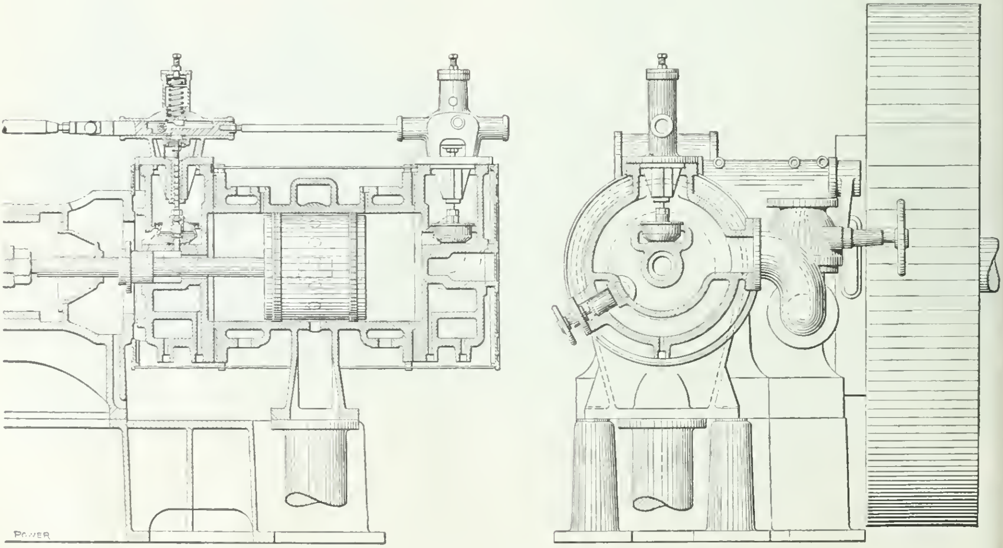


Fig. 3. Longitudinal and Cross-Section of Cylinder

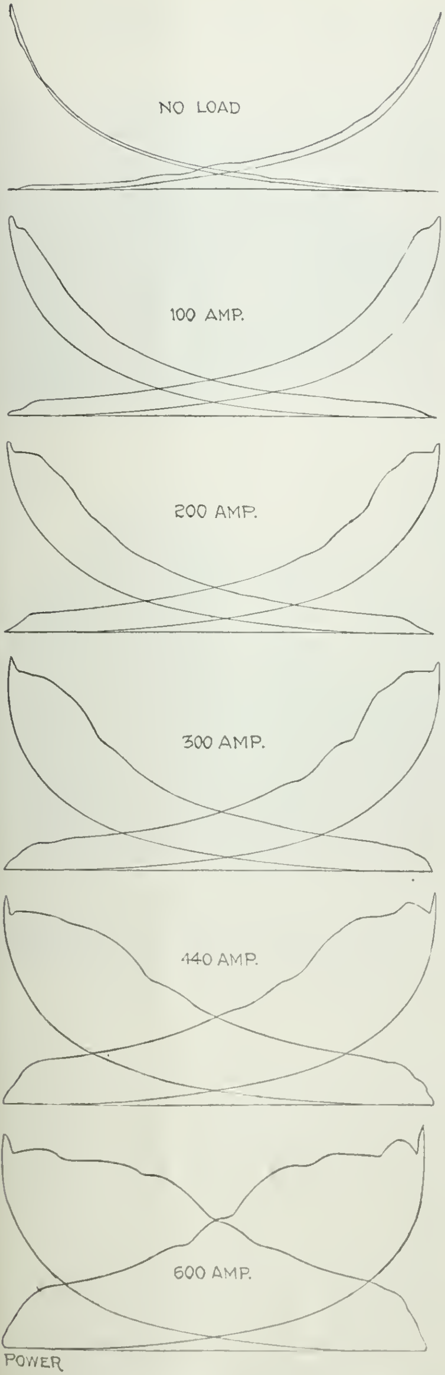


Fig. 5. Diagrams from No Load to 50 Per Cent. Overload

the engine designed to run noncondensing only has a piston, the head of which is turned out concave. This gives the required increase of clearance volume with the least possible amount of bounding surface. With an engine designed to run condensing a minimum amount of clearance is used, the piston being built in the usual way. In order to meet emergency conditions, as when the condenser drops its vacuum and the engine must run temporarily noncondensing, a clearance pocket is provided in the head, as shown in the cross-section in Fig. 3, the connection of which with the cylinder is controlled by the valve shown. When, for any reason, the engine has to run noncondensing, this valve is opened, connecting the pocket with the working cylinder and the clearance is increased and the compression kept down, although with a slight impairment of the efficiency on account of the addition to the containing surface. If desired the valve controlling the connection between this pocket and the cylinder may be made to open automatically, precluding the generation of excessive pressure by an accidental loss of vacuum.

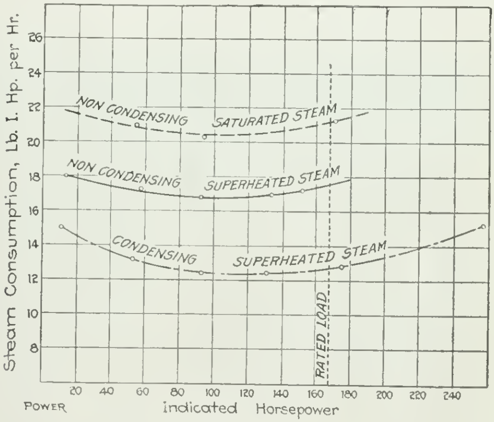


Fig. 6. Showing the Flatness of the Load Curve

The passages surrounding the cylinder between the exhaust belt and the cylinder heads are steam jackets, the motive of the engine being to preserve a hot end or zone for the entering steam; and as the exhaust does not come back through this zone it carries off no heat from it, which explains the economical results obtained by the unidirectional method of flow.

In order to adapt the engine to the use of high degrees of superheat, poppet valves are used, and one of the remarkable things about the running of the engine is the noiselessness and ease with which these valves are handled at 250 and more revolutions per minute. The operating rod extends across both valves as shown in Figs. 1 and 3 and receives its motion through a rocker arm from the governor eccentric. Where it passes through the valve bonnet, Fig. 2, its section is circular, with a recess in which is carried a roller. This roller, by contact with a suitably designed cam surface, lifts the valve quickly from its seat, and in closing permits it to approach the seat rapidly, but to be brought into actual contact at a diminishing rate which makes no perceptible impact. The cam is kept in contact with the lever, and the balanced valve upon its seat, by the spring shown at the top. The piston immediately below the roller-carrying section is merely a guide. The valve stem depends upon its length, good fit and water grooves for steam tightness, a method long ago used successfully by Professor John Sweet.

The well known difficulty of keeping a double-seated valve tight on both seats at the same time is met by making the upper lip of the valve sufficiently flexible to be pressed onto its seat by the steam pressure. Fig. 4 shows the valve on a larger scale. The cross-hatched portion is of cast metal. The upper lip, shown in solid black, is made by shrinking on a steel ring and then turning it to the section shown, the thin center deflecting enough under pressure to allow the outer ring to seat tightly.

The table on page 704 shows some results obtained with this engine upon the testing floor of the builder's shops at Oswego, N. Y., where they are exceptionally well equipped for such determinations. In Fig. 5 are shown a series of diagrams from friction to 50 per cent. overload. Steam consumptions of 12.5 and 17 lb. condensing and noncondensing are remarkable for an engine doing less than 100 hp. and the flatness of the curve of steam consumption plotted against load (Fig. 6) will give the engine a great advantage when used for light or fluctuating loads. These results were corroborated by the editor of POWER, who, on Oct. 16, made a test of the engine, assisted by Professors Herman Diederichs and W. M. Sawdon of Sibley College, and W. Trinks of the Carnegie Institute of Technology.

With an average load of 100.8 kw. the engine developed 168.46 i.hp., giving an overall efficiency of engine and generator of 80.2 per cent. With steam of 148 lb. gage, 125 deg. superheat and exhausting at atmospheric pressure the steam rate was 17.57 lb., the heat rate 19.022 B.t.u. per i.hp.-hr. and the efficiency referred to the Rankine cycle 75.8 per cent. Every precaution was taken to obtain correct results. The weighing apparatus, thermometer, gage and indicator were calibrated, the mean effective pressure corrected for a slight inaccuracy of the indicator spring, and there is no doubt that the engine will carry the load under which it was tested with the steam consumption given.

⁂

Cooling Tower for Oil-Engine Jacket Water

By William B. Garrison

While stranded for a few hours in a small town recently, I used the time in visiting several power plants in the vicinity of the railroad station, one of which is of interest. It has a 400-hp. twin oil engine, Fig. 1, directly connected to a 300-kw., 110-volt alternating-current generator, running at 150 r.p.m. A triple-plunger cooling-water pump is belt-driven from a pulley on the end of the engine crankshaft.

On the outside of the brick engine house is a long 9000-gal. capacity iron tank, above which are four stands of cooling troughs over which the water from the discharge of the engine water jacket flows, Fig. 2. Beginning at the right, the first and third stands cool the water from the engine. The second stand is connected to the overflow of a 6-in. standpipe, 24 ft. high, into which the belt-driven pump discharges, taking water from the iron tank. The top of the standpipe is fitted with a safety valve, set at 40 lb. pressure. When the pressure exceeds this, the valve operates and the water flows to the cooling racks. As the water jacket is piped to the standpipe under a pressure of 10 lb., it insures a constant circulation of water.

The water from the engine comes to the cooling towers at from 160 to 180 deg. and is taken from the tank at 90 deg., a drop in temperature of from 70 to 90 deg., during the winter months; in summer, the drop is less.

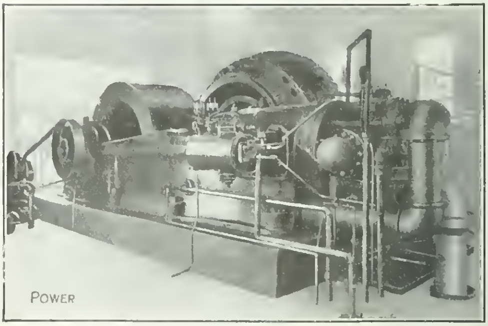


FIG. 1. TWIN OIL ENGINE OF 400 HP. CAPACITY

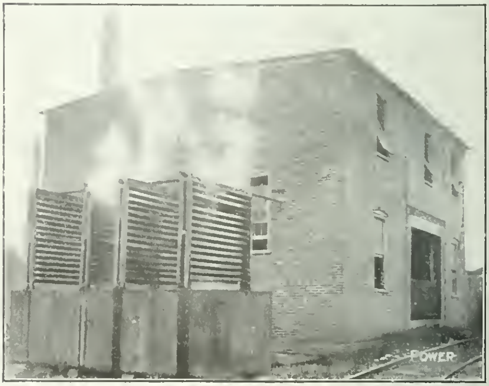


FIG. 2. COOLING WATER TOWER FOR ENGINE JACKET WATER

This cooling arrangement is a good example of what can be done cheaply when cooling water is not readily available at small cost and must be had.

The fourth cooling stand is used with a small crude-oil engine in the factory, but any one of the four can be used with either engine by controlling valves in the discharge pipe above them.

The exhaust gases from the engine go to a stack shown at the rear of the engine house, and are discharged vertically.

⁂

Profitable Municipal Plant at Lodi, Calif.—The city clerk's annual report shows that Lodi has cleared $17,183.22 on its municipal light and water system during the past year. The city owns property valued at $178,354, which includes the electric light and water plants and services. During the year the city received from the sale of water and lights, $47,174.93. It costs $37,916.93 to maintain these departments. In addition to this, improvements have been made to the plants amounting to $57,935.52, giving a real profit of $17,183.22.

Cost of Rapid Erection of Six 1000-Hp. Boilers

By Jay C. Lathrop

SYNOPSIS—The time, cost and details entering into the installation of six 1000-hp. stoker-fired water-tube boilers with superheaters.

During the past year, six 1000-hp. water-tube boilers have been installed in an addition to the Westport power station of the Consolidated Gas, Electric Light & Power Co., of Baltimore. There are eleven retort underfeed stokers under each boiler, the general arrangement being shown in Figs. 1 and 2.

These boilers are of the three-pass type, and are supported upon the structural-steel framework of the building. The front and rear headers are hung from two 15-in. 33-lb. channels framed between the main building columns by means of 3-in. round rods with ball joints. Each boiler has a heating surface of 10,170 sq.ft. and consists of 172 four-inch tubes 20 ft. long expanded into the wrought-steel headers, together with four steel drums each 35⅛ in. in diameter. Each boiler is equipped with a Foster superheater, arranged to heat 31,110 lb. of water to 187 deg. F. under a steam pressure of 200 lb. These superheaters are so designed that the drop in pressure shall not exceed ½ lb. at rated load, 2 lb. at 200 per cent of rating and 1½ lb. at 300 per cent. of rating.

The gases from each boiler are carried through a vertical uptake to a breeching varying from 5 ft. at the small end to 16 ft. at the connection to the stack, the width inside being 5 ft. The construction and method of supporting this stack on the steelwork were described in Power, Oct. 13, 1914, p. 522. Cross baffle-plates were arranged in the vertical portion of the breeching just beneath the stack, dividing the stack area into four sections. Each set of three boilers has a similar breeching, arrangement of which is shown in Fig. 3.

The setting for each boiler occupies a space 22 ft. 10 in. wide by 22 ft. 10½ in. long and 22 ft. 11⅜ in. high. The entire setting is supported upon the steelwork which carries the main boiler-room floor, 20 ft. above the basement floor.

Each sidewall, weighing 204,000 lb., is carried by two Bethlehem girder beams. The rear wall, weighing 34,500 lb., and the bridgewall, weighing 50,000 lb., are similarly supported. The front is taken up by the stoker, which also rests directly on steel floor-beams.

After the steelwork supporting the bridgewall and the reciprocating grates of the stoker had been erected it was found desirable to change the design of the stoker, making necessary the removal of one of the 18-in. beams supporting the bridgewall, and lowering the two beams beneath the reciprocating grate so that this grate could be lowered and placed further back, allowing more space for the clinkers.

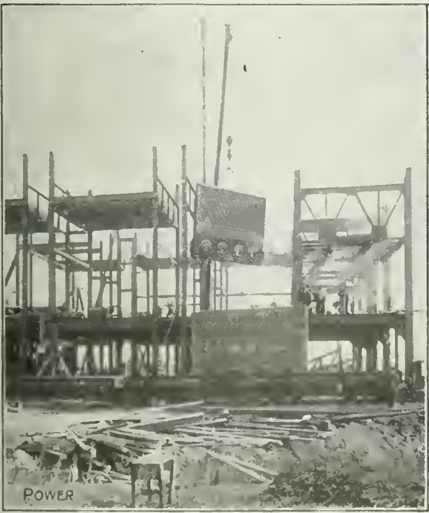


Fig. 1. Hoisting Header from Car

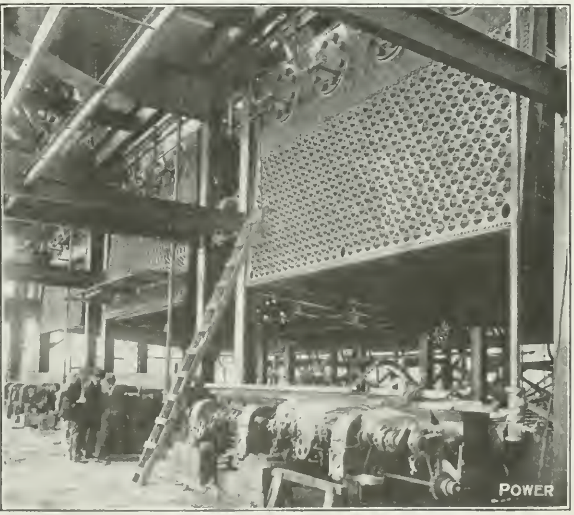


Fig. 2. Installing the Stokers

Stokers

The stokers are of unusual width, owing to the large capacity of the boilers, and each is made up of eleven standard retorts. The width of the stoker is 19 ft. 6 in. inside to inside of the combustion chamber, and the depth of the chamber is 8 ft. 3½ in. These stokers are provided with extension grates of the self-cleaning type which have recently been developed. This extension grate is showing up well under service, and is a desirable addition to the labor-saving machinery in a plant of this character. The forced draft for the stokers is provided by four three-quarter-housed paddle-wheel fans directly connected to four engines which also furnish the power for driving the stokers.

Erection of Boilers

The boilers were erected by the builders while the stokers were put in by the company forces under the direction of the contractor's superintendent. That no time might be lost in the construction, the boiler builders contracted with the steel erector to unload and place the heavy parts on the main boiler-room floor. The contractor used a large guyed derrick which easily handled the twelve headers and twenty-four drums, placing them approximately where they were to be erected, as is shown in the illustrations.

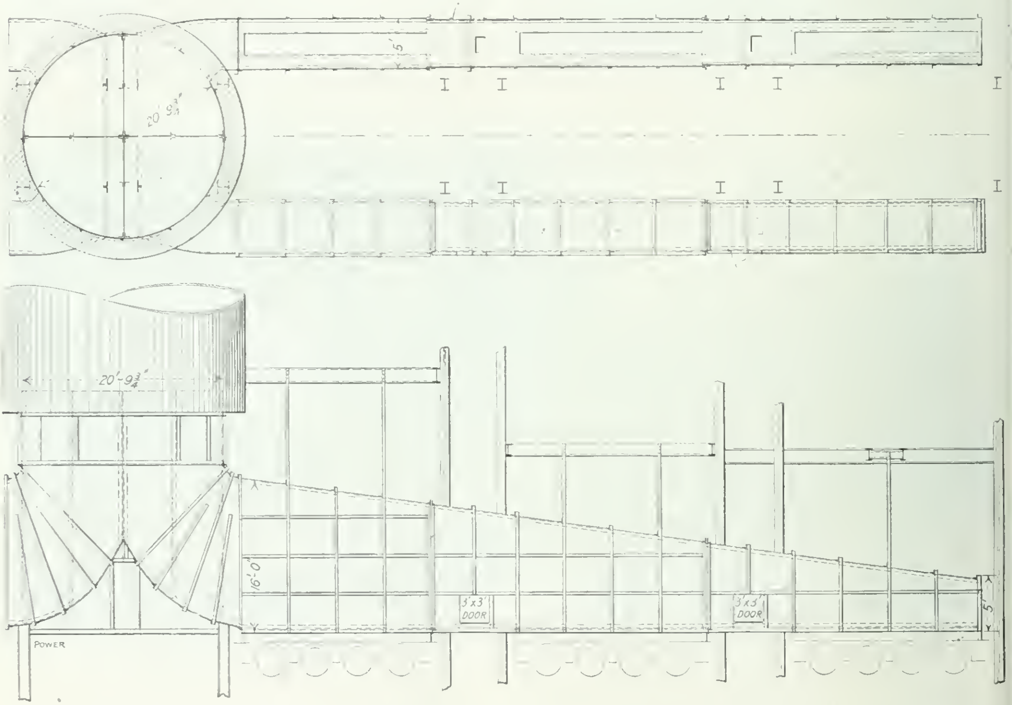


Fig. 3. Layout of Breechings (One Side) with Principal Dimensions for Six 1000-Hp. Boilers

Four cars of this material arrived on Jan. 27, two of which were unloaded on the 28 and two on Jan. 30. The unloading and placing were accomplished at a much lower cost to the boiler contractor than would otherwise have been the case, and with a minimum of interference with the work of other contractors.

The erection of boilers began on Feb. 2, and was finished on May 7, with the exception of certain minor details and alterations which were made later, making a total of about fourteen weeks, including the erection of the superheaters. The actual working time, including May 7, amounted to eighty-one working days.

Forty-one actual working days were required for the erection of the superheaters, which included seven days during which the foreman alone was on the job.

When it is considered that this work was begun the latter part of January and that the most severe weather in this part of the country occurred during February and March, this forms a remarkable record.

The following table gives in detail, the cost and the time required for the erection of the boilers and superheaters:

BOILERS		
Foreman, 81 days at $5	$405.00	
Labor, 8936 hours at $0.25	2234.00	
Total		$2639.00
SUPERHEATERS		
Foreman, 41 days	$205.00	
Labor, 2145 hours at $0.25	536.25	
Total		741.25
Grand total		$3380.25

As there were skilled men among the laborers used in the erection of the boilers and the superheaters, the hourly rate of 25c. has been assumed as an average covering both common and skilled labor.

Brick Settings

Each setting required about 54,000 bricks. The laying contract was made with a local contractor, the company agreeing to furnish all brick and material for mortar, the brick to be delivered on the main boiler-room floor.

Actual brick laying began on Apr. 7, 1914, and the entire work was completed on June 6, about five weeks after the erection of the boilers.

The following is the actual labor cost of this portion of the work:

Foreman, 51 days at $6	$306
Bricklayers, 2560 hours at $0.62½	1600
Laborers, 2368 hours at $0.25	592
Total labor cost	$2498

This is equal to $7.70 per thousand bricks.

Unfortunately, owing to the delay in the erection of the coal-handling apparatus and breeching, the boilers were not placed in service until Aug. 17, 1914, although fires were started in three of them on July 29, in order to dry the settings.

Stoker Installation

Unloading and erecting the stokers began Mar. 6, 1914, and they were ready to turn over early in July. The installation of the six stokers, together with four fans, four engines and the necessary shafting and hangers, required the services of an expert erector for 127 days, with labor assistance amounting to 50 days.

*

Lemb System of Boiler Setting

The chief disadvantage of the general method of bricking in boilers is the breaking of the brick headers after the furnace lining begins to burn away, allowing the lining to bulge and sag.

The Lemb system of boiler setting is designed to do away with the drawbacks of the ordinary boiler setting. The setting consists of interlocking and ship-lapped dry firebrick and block lining, interchangeable fire-door and back connection arches, etc., held in place by protected binders. Figs. 1 and 2 give an idea of how a horizontal return-tubular and a water-tube boiler are set in accordance with the system.

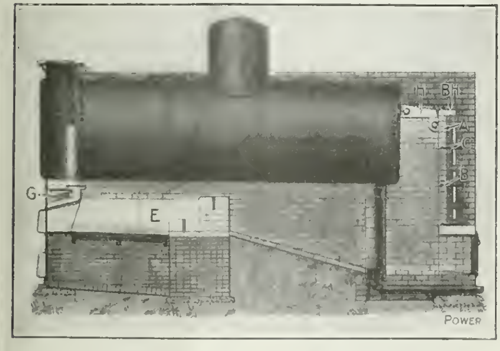


Fig. 1. Horizontal Tubular Boiler Set According to the Lemb System of Boiler Setting

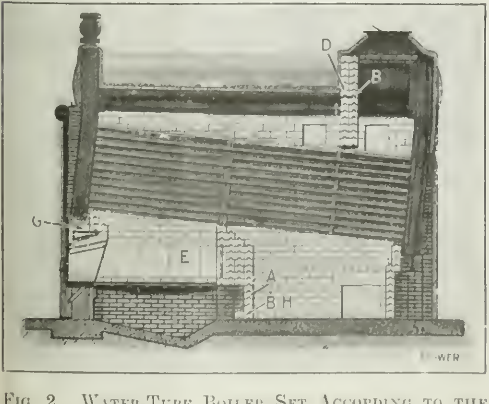


Fig. 2. Water-Tube Boiler Set According to the Lemb System of Boiler Setting

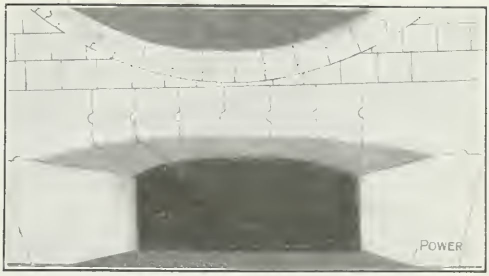


Fig. 3. Interchangeable Fire-Door Arch

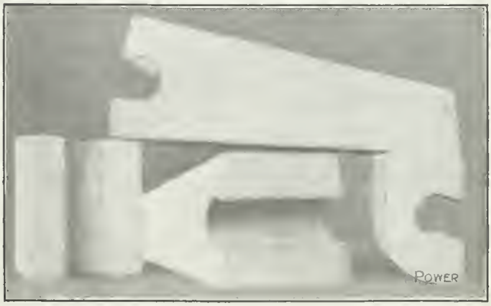


Fig. 4. Arch Block of the Back Connection Arch for Horizontal Tubular Boilers

Referring to Figs. 1 and 2, *A* shows the stretcher bricks and *B* and *BH* in combination with the binders form the headers; *C* is the binder for single walls and *D* that for party and baffle walls. The single-wall binders are anchored a full foot into the common wall; the binders for the party walls suit all thicknesses of walls. The firebox blocks *E*, made on the same principle as the brick, are 4½, 6 and 9 in. thick and 12, 18 and 24 in. high. The bricks, 3¼ in., are thicker than the standard firebrick; the width and length are the same as in the ordinary brick.

In the installation of this system, six stretcher courses are used between the header or binder courses. This brings them 2 ft. apart and makes the lining sectional, so that any one part can be removed or repaired without disturbing or interfering with any other part or section.

The burning-out sections of the firebox have a double lining, the furnace side being removable and of brick or block as conditions may require. Inasmuch as the brick and block are set dry, there is no settling. As the joints are knife-tight, but little clinkers will adhere; the linings are always fairly smooth. Owing to the strong tie caused by the binders, there is no bulging, sagging, or brick slipping out of place and there are no binders to break off.

The interchangeable fire-door-arch system, Fig. 3, consists of a series of sectional cast-iron, air-cooled arch plates, bolted to the boiler front. Movable hangers are suspended from the under side and interlocking arch blocks are placed on them; the hanger jambs and piers are similarly held in place. When the jambs, piers or arch blocks require renewal, the old blocks are pulled out and new ones slipped in. This is done without disturbing the brickwork above the arch plates. The dead plate can be removed at any time without its interfering with the arch system, which is independent of the dead plate or boiler walls.

The interchangeable back connection arch system, Fig. 4, consists of fire blocks supported by standard piping held in place by the boiler side walls. These pipes permit of air circulation and are protected from the hot gases.

The blocks conform as nearly as possible to the natural courses of the gases and are smooth. With this type of back connection arch, one or more of the sectional arch blocks can be removed. They are set without fire clay and so arranged that they cannot leak air. This back arch is also independent of the main boiler walls.

This system is controlled and the parts for it are made by John Lemb & Sons, Inc., 177-179 Marion St., Brooklyn, N. Y.

⁂

Broken Baffles

By Morgan B. Smith

SYNOPSIS—A hole in the first baffle of a Stirling boiler cut down capacity, lowered the efficiency from 78.8 to 28.2 per cent., and raised the temperature of gases leaving the boiler by about 350 deg. F.

⁂

The boiler which was examined, and in which a broken baffle was detected, is a 500-hp. Stirling, baffled in the usual manner. It is fitted with a steam-flow meter and electric pyrometers in the combustion chamber (top) and in the top of the last pass. It was the indications of the flow meter and the pyrometer in the last pass which gave rise to the thought that one or more of the baffles must be broken.

For some time the flow meter had indicated a sluggishness of steam generation which did not greatly improve with hard-driven fires. At the same time the temperatures of the gases passing to the stack, or breeching, had risen, on the average, something like 350 deg. F.

Before shutting down this boiler for repairs it was thought best to get together data bearing on its peculiar behavior. Consequently, readings of the steam produced and the temperatures in the top of the last pass, as well as over fires, were taken for a period of four days.

As the general figures for this boiler were known, those obtained at this time, with the boiler obviously in bad condition, could be compared with those found under normal conditions. After obtaining these figures the boiler was cooled down and examined.

The front baffle, possibly the most important of all three in this type of boiler, was found to have a hole in it 32x28 in. in size. This hole was irregular in shape and broader at the bottom than at the top.

The edges of the baffle brick around the hole were badly fused, so much so that they were rounded and there was some indication of actual fluxing. This, without a doubt, was caused by the intense concentration of heat as the products of combustion swept through this comparatively small opening. It is obvious that had the boiler remained on the line much longer serious tube trouble would have developed at this point.

The results of such a broken baffle are, in general, diminished capacity, since contact of the heated gases with the tubes is greatly lessened; distortion of the tubes in the immediate neighborhood of the break, with possible ultimate failure; diminished efficiency of combustion; disturbed circulation and, probably, foaming. Fig. 1 shows graphically the working conditions of this boiler, especially the temperatures found at the top of the combustion chamber and in the top of the last pass.

The average temperature over the fire is 2462 deg. F.; at the top of the first pass, 1148 deg. F., and at the top of the last pass, 545 deg. F.

Fig. 2 shows the change in conditions after the breaking of the front baffle. The rise in temperature at the top of the last pass explains at once the falling off in the evaporation in this boiler. The fire was maintained as closely as possible at the average temperature generally maintained in this furnace, viz., 2462 deg. F.

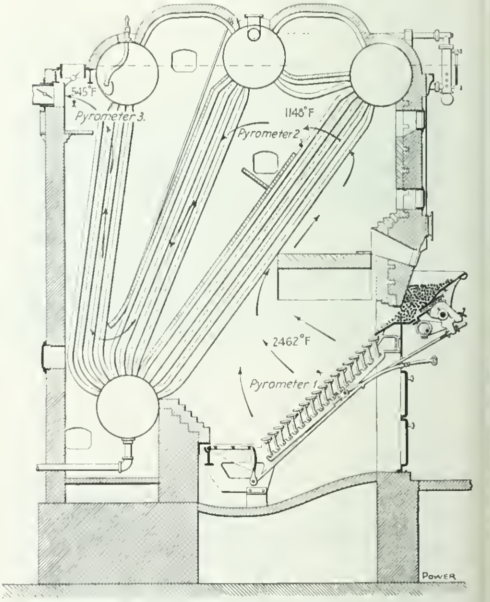


Fig. 1. Normal Working Conditions in the Boiler Investigated

It was not possible to locate the break in the baffle before shutting down the boiler; hence no temperatures could be taken at the point of rupture in the baffle. It is probable, however, that the temperature at this point did not fall much from that in the furnace since the contact with the tubes in the front bank was limited.

The temperature was estimated, considering the known softening point of the baffle brick, at close to 2372 deg. F.

Considering the short cut which the gases took through the tubes it is remarkable that the temperature in the top of the last pass was not higher than found, viz., 1778 deg. F.

Summarizing the temperatures found in normal practice and those found under conditions imposed by the broken baffle, we have:

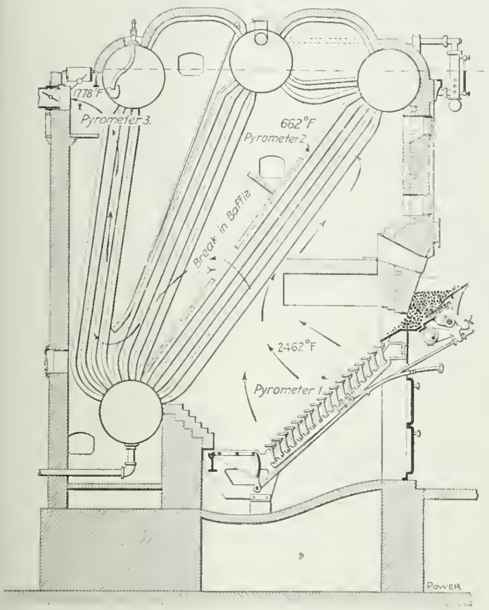


Fig. 2. Showing Break in Baffle and Resulting Temperature Conditions

TEMPERATURES IN DEG. F.

	Pyrometer No. 1 Over fires	Pyrometer No. 2 Top of first pass	Pyrometer No. 3 Top of last pass
Normal	2462	1148	545
Abnormal	2462	662	1778

Heat Absorbed

Normal conditions: In first pass, 54 per cent. First to third pass, inclusive, 21.7 per cent. Total heat absorbed, 78.8 per cent.

Abnormal conditions: In first pass—doubtful. Total heat absorbed, 28.2 per cent.

The loss in evaporative effect in this boiler, due to the broken baffle, was, therefore, roughly in proportion to the heat absorbed or the difference between the temperatures observed at the top of the last pass, the ratio being 545:1778. Thus, the boiler after the rupture of the baffle showed less than one-third the efficiency it had shown under normal conditions. These figures were checked by the readings of the steam-flow meter.

The point is that efficiency is at once lowered, often seriously, when the products of combustion, heated gases, are allowed to pass through the heat-absorbing surfaces without proper contact. The installation of pyrometers in the top of the last pass, fitted with recording devices, if possible, is a ready safeguard against operating for any length of time with baffles out of order.

The case here described is possibly a somewhat exaggerated one, but serves to illustrate the importance of the topic under discussion. What is true of this particular boiler is also true of other types in which baffling is employed in order that the contact of the gases with the heat-absorbing surfaces may be kept at a maximum.

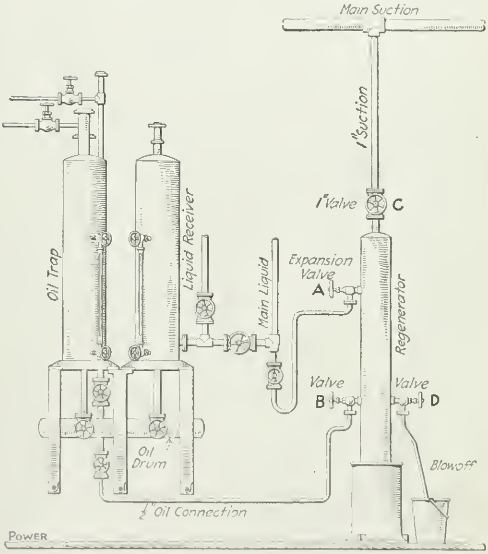
Baffles should be examined every time the boiler is down for cleaning and the smallest cracks found should at once be cemented tightly; it is at these small openings that heat, concentrating, gradually forces a larger and larger opening until failure of the baffle is the result.

Pyrometer tests are easily made; the apparatus required is not expensive and the time required is practically *nil*—therefore, watch your baffles.

⁂

Vilter Ammonia Regenerator

The Vilter Manufacturing Co., Milwaukee, Wis., has recently placed on the market an ammonia regenerator to be used for keeping the charge of ammonia in the system in an anhydrous condition. The regenerator is connected to the liquid side of the system instead of to the suction side, and the impure ammonia is supplied to it and cleaned from its impurities by a process of evaporation.



The Vilter Ammonia Regenerator

Referring to the illustration, the liquid ammonia with its impurities comes to the regenerator from the liquid receiver, oil drum or ammonia condenser to the valves *A* or *B*.

On entering the evaporating drum, the ammonia is relieved of the pressure which held it in a liquefied state and expands into a gaseous form. The vapor passes out of the drum through the valve *C*, connected to the nearest suction line by a one-inch pipe. To accelerate the vaporization of the liquid ammonia, a water jacket is provided, the water being taken from a feed-water heater or other source whose temperature is from 150 to 180 deg. F. If desired, a small steam pipe may be connected to the water jacket. The jacket is internal to the drum, an internal heating coil or pipe being avoided to obviate the possibility of damage due to bursting of the heating pipe through freezing of the water in it.

The interior of the shell has a cast-iron distributing plate circumferentially perforated and placed immediately below the inlet *A*; this plate acts much the same as that in a puddle carburetor. In operation, the outlet valve *C* is opened wide, all other valves being closed. The water to the jacket is then turned on, after which the expansion cock *A* is opened slightly. The drum will now commence to frost, and the cock *A* may be slowly opened wider to increase the flow of liquid until the upper part of the drum becomes frosted. Care should be taken that the frost does not continue along the suction pipe past the valve *A*. This may be controlled by manipulating the expansion cock.

After about twenty-four hours' operation, the valve *A* should be closed until the frost has disappeared from the drum, after which the valve *B* should be closed tight. The blowoff valve is now opened, and the impurities or residue from the ammonia is drained from the drum. If the ammonia is very impure, it will, of course, require more than twenty-four hours to take out all of these impurities.

All the connections are shown in the illustration.

* *

Some Common Elevator Troubles

By Albert H. Israel

SYNOPSIS—Besides the many electrical troubles met in caring for electric elevators there are also numerous mechanical ones. The most important of these are considered. The article is timely, due to the workmen's compensation laws now in force in many states.

*

Testing the Safeties

When the speed exceeds a limit set by the building or other department of the municipality, the governor and the safety device which it is supposed to operate are of little use if the governor has not been adjusted properly. There are governors which will not even rise at the desired maximum speed.

The safety device under the car, the guides, the governor with all its parts, and the governor rope are surely most important, for the safety of the passengers depends upon these parts being in good condition. Often the gripping cams will hug the governor rope when the car overspeeds but they will not grip it; then the gripping faces of the cams should be filed to the right shape or the cams renewed. For this reason, when making a runaway test one should not be satisfied with merely seeing the cams beginning to hug the governor rope when the speed of the car is near the maximum allowed; one should see the safety brake actually thrown in when the permitted speed has been reached. Runaway tests are not beneficial to the elevator mechanism, especially to the guides, and frequently they require considerable scraping after a test.

Usually, the easiest way of ascertaining the speed of the car is to make a heavy chalk mark on the winding drum at a certain point and then, by means of a good stopwatch, get the number of seconds it takes to make a definite number of turns of as nearly constant speed as is obtainable. The speed is found from the equation

$$S = \frac{R \times C \times 60}{T}$$

where

R = Revolutions of drum;
C = Circumference of drum in feet;
T = Time in seconds in which revolutions of drum were made;
S = Speed of car in feet per minute.

It is well to place a metal guard over the sheave to prevent the governor rope jumping off and breaking parts of the governor or injuring the rope after the governor has acted.

Wherever an idler pulley is required under the car for the governor cable it should be securely fastened, otherwise when the governor acts it may fall to the bottom of the shaft or injure the rope.

The law generally requires that there be two and one-half turns of governor cable on the safety drum when the safety has gripped the guides, but since the adjustment may change somewhat, one should unwind the cable at regular intervals to ascertain if there are at least this many turns. The reason for this law is to make certain that the safety will grip when the governor acts.

Care of the Band Brake and Counterweights

It should be needless to say that the unusual wearing of the ropes is sometimes caused by their rubbing against some surface in the shaft. This fault should be easily discovered by an examination of the cable and the shaft.

When the band brake has been removed for any reason and is put back into place, one should make sure that it has not been bent out of shape. If it is, it may bear hard in some places even though it may seem entirely free of the pulley and so cause the motor to draw an excessive current.

The ropes to the lower counterweights, unless properly protected by tubing, may wear where they pass through the upper counterweights. The tubes should be long enough and clamped to the lower counterweights; if allowed to remain loose, they may themselves prove dangerous to the rope.

Each set of counterweights should always be securely bolted together. In old installations where this has not been done, they should be strapped together with strong iron bands. The importance of this will be seen if we imagine the car stopped suddenly near the bottom of the shaft by the safety, and, due to the sudden shock, some weights are shaken off and dropped down the shaft onto, and perhaps through, the roof of the car.

Bent and Worn Guide Shoes

Now and then the guide shoes will be found too loose or too tight, out of line or broken or worn to such an extent that they require replacing. A broken shoe-spring may be the cause of the looseness. When the spindles of the shoes are found bent it may generally be shown that the car has run into the overhead work or struck bottom at some time or other. When the upper shoes are bent from this cause, the grating is frequently bent upward.

The guides frequently become troublesome through no fault of their own, especially if they are insufficiently lubricated or if a bent shoe starts scraping. When first installed, they should have the proper strength and be securely fastened to the girders; if this is not done, there may be a considerable wreck when the first runaway test is made by the building department inspectors.

A loose grating at the top of the shaft is not an uncommon source of danger to the passengers, the operator and to those whose duty it is to examine the overhead work. Since it is so easily remedied, a loose grating should never be allowed to continue.

The latches on ordinary doors are a source of peril to inquisitive people. When the latch is so worn that it will no longer lock properly, persons are likely to look into the hatchway with the all too often fatal result. A person who is ignorant enough to put his head through a hole in a door to see whether the car is coming will surely not hesitate to open the door if he can.

Proper oiling of the various parts is essential whether the parts in contact are frequently in motion or not. A part not oiled will sometimes rust until it becomes immovable. This is particularly so of those belonging to the governor mechanism and the safety drum under the car. The lack of oil on the latter, together with the water allowed to seep through a nonwaterproof floor, will in most cases produce corrosion of the machinery. The writer recalls one occasion where a worm-gear shaft bearing was allowed to become so hot at the rear end, due to the lack of oil in the gear case, that the bearing metal "froze" to the shaft when the machine stopped.

Systematic inspections at regular intervals by reputable insurance companies should always be welcome. The professional inspector will find troubles which would probably remain undiscovered for a long time if the inspections were left to the house force alone.

Will Quiz, Jr.

SYNOPSIS—Will Quiz, Jr., wants to verify Chief Teller's statement in a previous chat to the effect that the boiler is a more efficient machine than the engine; and, true to his nature, asks more questions.

⁂

"One statement you made lately seems strange to me."

"What was that, Will?"

"You said the boiler was a more efficient piece of apparatus than the engine; can you show me?"

"That's right, Will; take as little as possible for granted; there are some things which must be taken on statement for the time being, but they should be looked into and proved or disproved later.

"Let's see, we found that 14,070 B.t.u. coal theoretically should evaporate, from and at 212 deg., 14.5 lb. of water per pound of coal. What is the best boiler-test evaporation you can remember just now, Will?"

"It seems to me it was nearly 12 lb.; 11.6 would be equal to 80 per cent. efficiency, would it not?"

"Yes; but 80 per cent. is high for everyday practice. Suppose we use about 9.5 lb. evaporation, which would be about 65 per cent., or, expressing it in the same way that we did in the first instance, where the actual heat energy in a pound of coal is equal to 5.5 hp. for an hour, the heat energy delivered in the form of steam by the boiler at 65 per cent. efficiency is equal to about 3.5 hp.-hr. Now, how does the engine use the heat sent to it? Suppose the engine uses 19 lb. of steam per horsepower-hour, or twice 9.5 lb., the boiler's output in evaporation per pound of coal, or twice the 3.5 hp-hr. referred to. Then the engine gets enough heat energy to produce 7 hp. for an hour and only delivers one—i.e., 2 lb. of coal, or

$$14{,}070 \times 2 \times 0.65 = 18{,}291 \textit{ B.t.u.} \times 778$$

(the mechanical equivalent) divided by 1,980,000 ft.-lb. per hp.-hr = 7. In other words, the engine requires seven times the heat it should, or is about 14.3 per cent. efficient. The best engines only transform about 20 per cent. of the heat energy supplied to them into work, and many do no better than 4 or 5 per cent. The steam engine, in fact, all kinds of engines, are simply heat motors, and the loss in the heat contained in the fluid in passing through as compared with the power output is the measure of efficiency.

"Since 2545 B.t.u. equals 1 hp-hr., that is the amount chargeable to useful work, and all the rest is wasted in friction, radiation and the exhaust steam."

"But, Chief, the difference in the total heat in 19 lb. of steam at the different pressures by the table does not allow enough B.t.u. for a horsepower-hour."

"No, it is the latent heat in that part of the steam which has returned to water, or the degree of wetness of the exhaust steam, which accounts for the B.t.u. used. In the case cited of 19 lb. of steam per horsepower-hour, you would find about 2¾ lb. of steam had given up its latent heat and become water. This gives the same result as before—that is, a little over 14 per cent. efficiency for the engine; 14.3 per cent. of 19 = 2.72 lb."

"But, Chief, suppose the exhaust steam is used for heating buildings; then the engine would not be charged with the heat in the exhaust steam and its efficiency would be called 85.7 per cent."

"Yes, Will, looking at it that way it is good, and I am glad you caught that point, because if the exhaust is made use of for heating or other useful work, not simply condensed, then the engine is not to be charged with more than the heat actually lost in it, which, as you have seen, is not much in excess of the energy reproduced in the form of work. But the boiler is charged with all the heat wasted in producing steam, including the waste in the stack gas, so for comparison the engine as a unit must be charged with all the heat delivered to it."

Front-Feed Stokers*

By Osborn Monnett†

SYNOPSIS—How this type of stoker should be set under return-tubular and water-tube boilers. Full instructions for smokeless operation.

*

Under this classification come all stokers of the inclined type fitting in at the front of the boiler and having a shaking or dumping grate at the bottom near the bridge-wall. One of the principal points in its design is not to get the angle of inclination great enough to cause avalanching of the coal and at the same time have the angle sufficient so that the fuel will feed freely without having to be pushed in by hand from the front.

Moore Stoker

This consists of a series of cast-iron steps at a general angle of about 37½ deg. Water circulation, passing from the lowest step upward in regular order to the top step and then to the gate, is provided. In between the cast-iron water-cooled steps are pushers made to withstand the action of the heat. Normally they rest at a point not subjected to high temperature and are only in the fire long enough to push the coal from one step to another, according to the demand for steam.

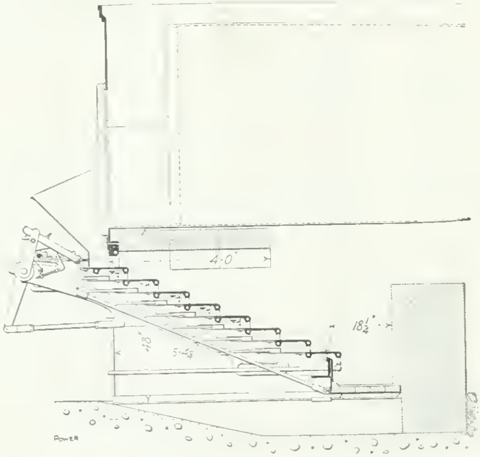


Fig. 1. Moore Stoker under Return-Tubular Boiler

The dumping arrangement consists of a cast-iron fire-brick-lined carrier on wheels, which can be pulled out from in front by a hand lever. The operation is simple and no cleaning is required, the clinker, if any, forming in the shape of small lumps the size of a man's fist and dropping into the ashpit.

When installing this stoker under a horizontal return-tubular boiler, the chief requisite is to have sufficient headroom for an ignition arch over the grate. The stoker is set flush front and 48 in. is all that is required for a 72-in. by 18-ft. boiler. This unusually low headroom gives the stoker certain advantages when applied to settings limited in height or to existing hand-fired plants set too low for good hand-fired furnace design. In the case of laundries or dye houses, the hot water from the stoker can be used to advantage in the manufacturing processes, while in other cases it is available for feed water. The stoker eliminates the human element to a large extent. It requires no poking and the cleaning period consists of dumping the ash from time to time. Fig. 1 shows an installation under a return-tubular boiler. The high bridge-wall has as good an effect on the performance of the stoker as with the chain grate or a hand-fired furnace. Limitation to the height of the bridge-wall is the necessity of leaving above it an area not less than 25 per cent. of the grate surface.

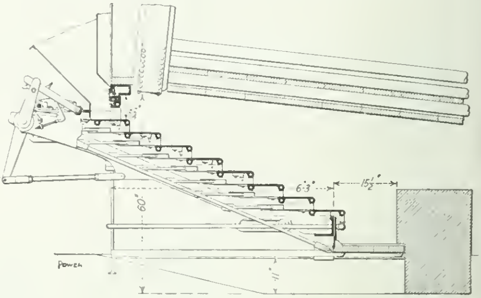


Fig. 2. Moore Stoker under Heine Boiler

Fig. 2 shows a Moore stoker applied to a horizontally baffled water-tube boiler of 175-hp. capacity. The grate surface is 40½ sq.ft. and from the floor line to the bottom of the front header the distance is 60 in. The box tiles on the water tubes act as the ignition arch and give enough flame travel to mix the gases. The stoker can be placed under any water-tube boiler and the low headroom maintained if the boiler is horizontally baffled. An installation under a vertically baffled boiler should not be attempted without a long ignition arch sprung over the furnace and a headroom of at least 9 ft. 6 in. under the front header.

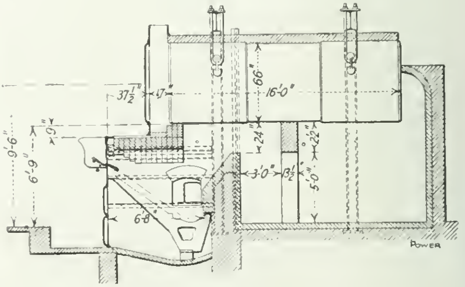


Fig. 3. Return-Tubular Boiler Equipped with Roney Stoker and Deflection Arch

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, City of Chicago.

Feed ashes into the hopper until the grates are covered and start a fire at the grate with oily waste or with live coals from another furnace. When the coal or waste has ignited, feed the stoker slowly by hand until a good bed of fuel is on the grates. Then open the damper and let the engine run the stoker in the usual way. When ashes accumulate on the dump grate, pull out the lever provided for the purpose of dropping them into the ashpit. Regulate the speed of the engine in accordance with the demand for steam and keep the grates as nearly covered as possible. There is no cleaning period for this stoker and no necessity for working it from the sides. To make it smoke-proof, the damper should not be closed when any considerable quantity of fresh coal is on the grates.

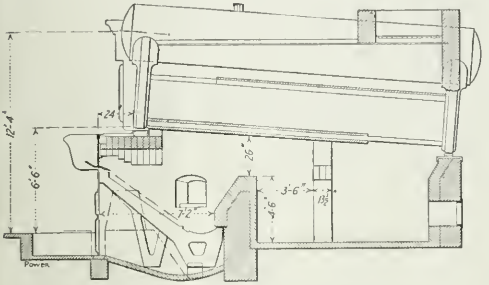


Fig. 4. Roney Stoker and Two-Span Deflection Arch under 185-Hp. Kroeschell Boiler

Banking and Breaking Up Fire

Feed in a considerable quantity of coal rapidly with the hand lever. Close the damper and leave the water circulation on the grates.

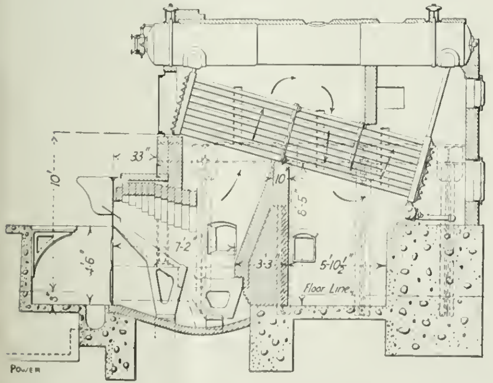


Fig. 5. Roney Stoker and Vertically Baffled B. & W. Boiler

When breaking up the fire, open the damper and wait until the fuel has properly ignited before regular operation is resumed. When starting the fire on a Moore stoker, always be sure that the water circulation is turned on and have the outlet in such a position that the overflow can be seen at a glance by the fireman.

Roney Stokers

A Roney stoker under a return-tubular boiler is shown in Fig. 3. The headroom is that required to get in the ignition arch under the shell of the boiler. This can usually be done on 72 in. when it is possible to excavate the ashpit to some extent. In the particular instance shown in Fig. 3, the headroom is 81 in., due to the relieving arch. In operating this stoker, there are times when an excessive amount of volatile matter is likely to be driven off. A successful safeguard in taking care of these periods is shown in Fig. 3 in the form of a two-span deflection arch behind the bridge-wall. This breaks up the gases and has been a great help in running such a setting clean.

In applying the Roney stoker to water-tube boilers it is generally safer to use the horizontal baffle in cases where the smoke question is of prime importance. Fig. 4 indicates a typical installation of this stoker under a Kroeschell boiler, set 6 ft. 6 in. from the floor line to the front header, with an excavated ashpit. Behind the bridge-wall is a two-span deflection arch with an area under the arch equal to 50 per cent. of the grate surface.

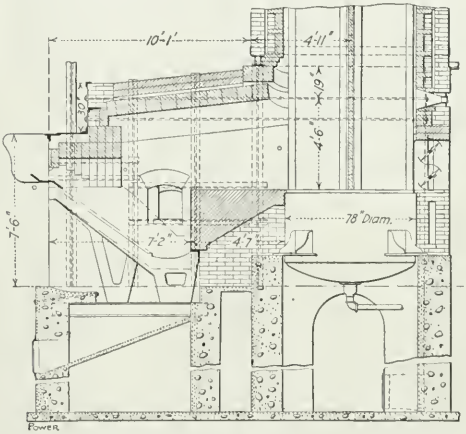


Fig. 6. Wickes Vertical Boiler, 250 Hp., Served by Roney Stoker

With vertically baffled water-tube boilers the prime necessity is flame travel. This can be obtained only by setting the boiler high enough so that combustion will be completed before the gases enter the bank of tubes. Fig. 5 gives the details of such a setting. The boiler is of the B. & W. type, set 10 ft. above the floor. This should be the minimum headroom allowed for this type of boiler. Set in this way, with good bridge-wall design, the flame travel is sufficient to give good results.

In the case of vertical boilers, it is a simple matter to apply the Roney stoker and get all the flame travel necessary. Fig. 6 shows a typical illustration of the stoker under a Wickes boiler. In this installation the high vertical bridge-wall reflecting its intense heat onto the grates is an important factor in smokeless operation. Also, it provides an obstruction against which the gases must impinge before passing to the heating surface, so that a more thorough mixture of the gases is obtained. This is of special importance when an excessive amount of volatile matter is passing off.

How to Operate a Roney Stoker

After the grate has been covered with coal and a fresh wood fire started on top of the fuel, open the damper partly until the fuel has been completely ignited. Then the damper can be opened wide and the stoker fed slowly until the arch is heated up. As in chain-grate operation, the grates should be kept as thoroughly covered with fuel as possible, considering the load, as cold air coming up through any part of the fuel bed will interfere with efficiency. This can be regulated by the frequency of the feed.

CLEANING FIRES

First, pull up and fasten the rods that lift the guard grates. This will break the clinker free from the grates, permitting the refuse to drop into the ashpit when the dumping grates are tipped. The guard grates should be kept in the upper position until the dumping grates are closed, to prevent live coals on the lower grates from dropping into the ashpit. If a clinker should catch on a dumping grate, break it loose and pull it out with a hook, but do not disturb the fire on the upper grate. After the ashes have been dumped, close the dumping grates, then unhook the guard-grate rods and return them to their normal position. If the cleaning is done properly, there will be no necessity of poking the fire to cover the lower grates. Poking a Roney stoker is one of the most frequent causes of smoke.

Do not shake the guard grates in an effort to get out all of the clinker, because in so doing good coal will drop into the ashpit and the lower part of the grates will become uncovered. Only clean one furnace at a time and allow a considerable interval to elapse before working another fire.

Never work a fire through the side inspection doors, as this causes the coal to avalanch and produce smoke. Regulate the length of the fire by the speed of the stoker and do not poke between the bars from the front; this frequently causes a large part of the fire to slide down on the grates and a considerable quantity of fresh coal to be dumped suddenly into the fire, causing smoke. If a sudden demand for steam occurs, speed up the stoker. In case the steam pressure goes up, do not shut the ashpit doors but slow down the stoker to prevent popping. In case the steam pressure still goes up, stop the stoker entirely and after the volatile matter is burned off, carefully close the damper. Do not close the damper on a thick, heavy fire containing fresh coal, as smoke will be made. Always leave the ashpit doors and dampers wide open on a normal working load.

⁂

Planet Steam Soot Blower

A soot blower for return-tubular boilers, which is mounted on the flue-cap door and can be operated while the boiler is in operation, has been completed recently by the Bennett-Dluge Co., of Detroit, Mich.

The construction and arrangement are shown in Figs. 1 and 2. Primarily, the blower consists of a square telescoping arm provided with a number of steam jets. By means of gearing and a handwheel exterior to the boiler the arm is moved across the face of the tubes. Its movement is guided by the cam track shown in Fig. 1, the path of the extreme jet being indicated by the dotted line. The blower is mounted in a bracket bolted to the door and through the supporting pipe steam is admitted to the arm. With the number of jets shown, all blowing at one time, one passage of the arm over the flue sheet covers all of the tubes. As shown in Fig. 2, the jets are close to the flue sheet and blow into the tubes. Unscrewing the union at *A* allows the door and the blower to swing clear.

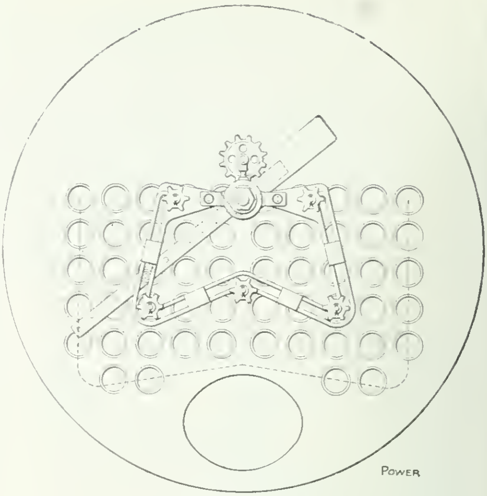


FIG. 1. TELESCOPING ARM AND CAM TRACK

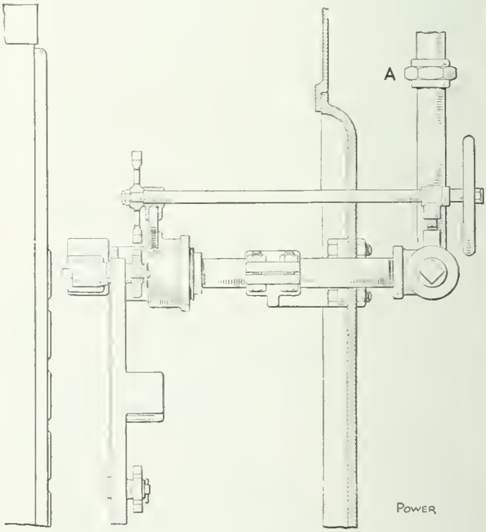


FIG. 2. STEAM JETS ON THE SQUARE TELESCOPING ARMS

⁂

Stored Heat—In Germany a state dinner was to be given in a castle which had no heating system. The engineers were asked to heat the building for the dinner; but it was specified that no portion of the heating system was to be visible in the room. The result was accomplished by means of stored heat. For a number of days previous to the dinner, the floor of the dining room was covered with steam pipes and these pipes were kept hot by means of a temporary boiler. The day before the dinner all the pipes were removed and the stored heat in the walls maintained the room in a perfectly comfortable condition for a number of days, although the outside temperature was well below the freezing point.

Curves of the Properties of Saturated Steam

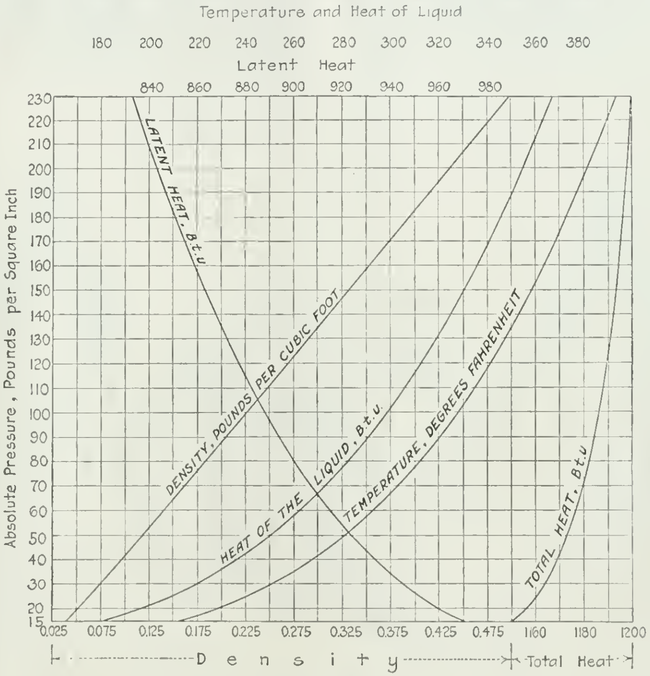
By Julian C. Smallwood

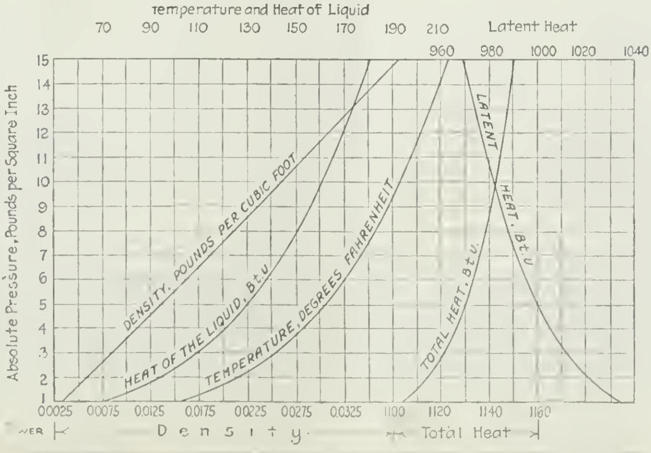
FOR certain classes of work, it is desirable to have approximate data upon the properties of steam, obtainable for rough calculations without the necessity of hunting up steam tables; for steam engineers, especially, a pocket reference giving such data is often as important an item of personal equipment as a slide rule. On this account the accompanying chart based on **"Marks and Davis Steam Tables"** has been carefully prepared.

By its use, the heat quantities may be read to the nearest unit; that is, to within one-half of one B.t.u. or degree F. for any pressure between one and 230 pounds absolute. The upper part of the chart deals with pressures above atmosphere, and the lower part, pressures below atmosphere.

To use the chart, find the given pressure on the left-hand scale, and follow the horizontal line at this pressure until it intersects the curve of the property sought; then follow vertically to the corresponding scale.

If temperature is given instead of pressure, use the temperature curve in place of the scale.





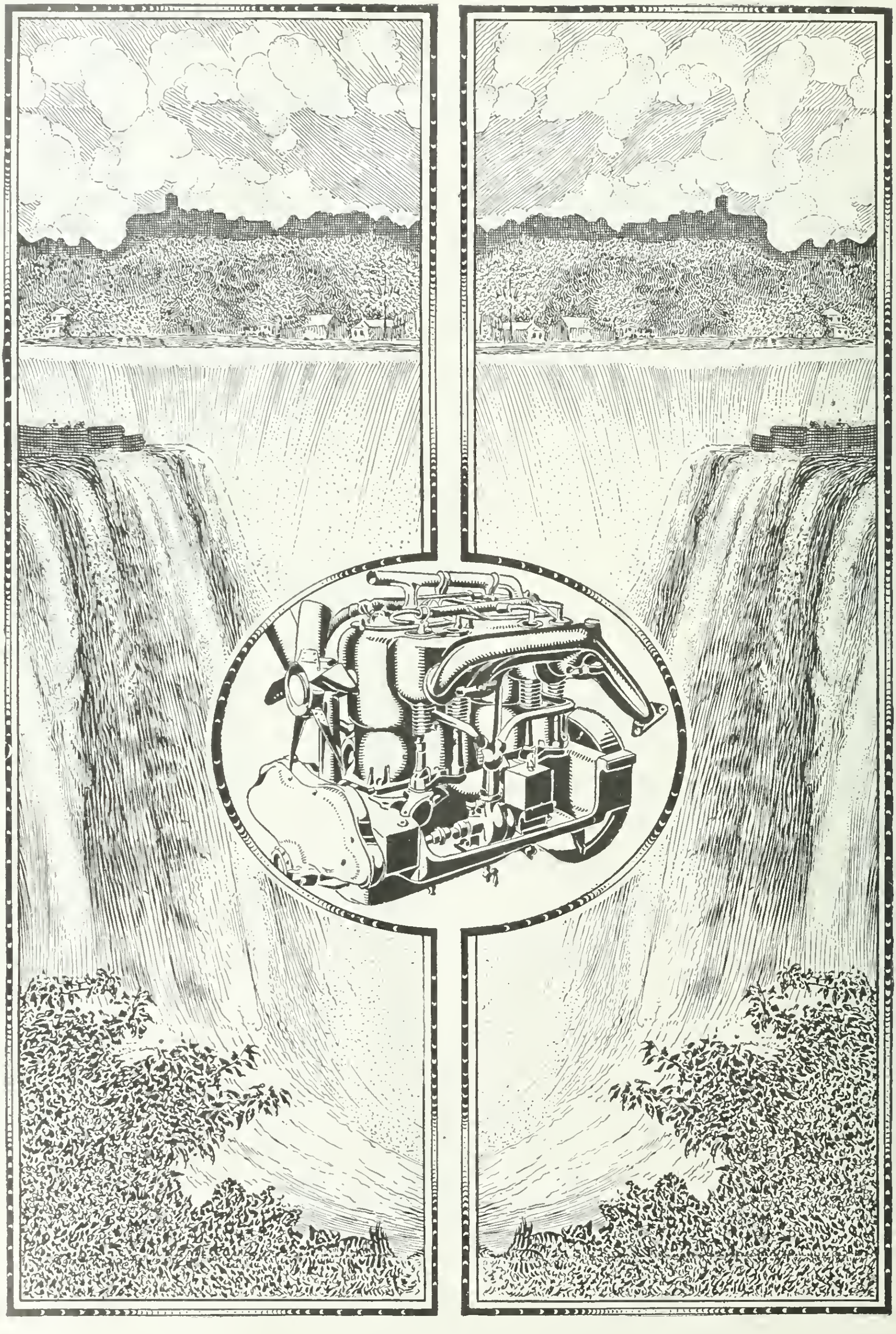
Example 1—Find the latent heat, density, temperature, heat of the liquid, and total heat of steam at 155 lb. absolute.

Solution—For 155 lb. it is necessary to interpolate between the 150 and 160-lb. lines. This would cross the latent heat curve between the ordinates 860 and 865 B.t.u., corresponding to about 861 B.t.u. Similarly, it would cross the density curve at 0.342, the temperature curve at 361 deg. F., the heat of liquid curve at 333 B.t.u., and the total heat curve at 1194 B.t.u.

Example 2—Find total heat in 1 lb. of steam at 193 deg. F.

Solution—As 193 deg. is below 212, which corresponds to atmospheric steam, we must look to the lower part of the chart covering pressures below atmosphere. The 193-deg. point is found on the temperature curve where it intersects the line of 10-lb. pressure. Following this pressure line horizontally to the total heat curve, we find 1143 B.t.u.

The properties of wet steam may be readily calculated when the percentage of moisture is known.



The Aggregate Power of the Automobile Engines Manufactured Last Year in This Country Is Equivalent to Twice the Potential Power of Niagara Falls, or 13,500,000 Horsepower

Locating Faults in Direct-Current Armatures--II

By F. A. Annett

SYNOPSIS—Causes of short-circuits in armature coils, their symptoms and how repairs may be made.

⁂

A short-circuit in an armature may be caused in several ways: First, one or more turns of the same coil may come in contact with each other, as indicated by the dotted line *s*, Fig. 1. This, however, can occur only where the armature coils are wound with more than one turn. To eliminate complications in the diagram, the winding is shown with only one turn per coil, which is the case in large machines or those wound for low voltages. A condition, as shown, will cause excessive heating of the faulty coil, and will burn it out in a short time.

The cause of the heating in the coil will be understood, when it is remembered that the faulty coil makes a closed circuit on itself. Consider the winding moving by the pole pieces in a direction indicated by the arrow *t*, in which case conductors under the respective poles will have electromotive force induced in them, as shown by the arrow-heads. This will make brushes B_1 and B_3 positive and B_2 and B_4 negative terminals, but no current can flow through the winding, until the external circuit is closed. If coil 7 is closed as indicated by the dotted line *s*, a current will flow around in the coil, and as the resistance of the coil is low, the current will soon reach a value sufficient to increase the temperature to a point where it will destroy the insulation, and may also destroy other coils located in that region, unless the faulty coil is soon detected and repaired. Usually the faulty coil can be easily located by running the machine for a short period, say half a minute, and then feeling with the hand; the defective coil will be much hotter than the others. Care should be taken in doing this, for the excessive heat generated in the defective coil will soon spread to the adjacent coils. If there is any doubt as to the defective coil, the armature should be allowed to cool, and the test repeated. Another indication of the defective coil, is a softening of the insulating compound in the insulation, and sometimes smoke emanating from the coil, if the armature has been allowed to run too long while making the test. If the coil is burned out, it is easily detected by the charred condition of the insulation.

After the defective coil is located, to repair it will necessitate removing the armature from the machine, taking out the coil and either making a new one or re-insulating the defective one, and placing it back in the winding. This requires considerable time and it may be inconvenient to have the machine out of service for so long a period. Fig. 2 shows a rough and quick way in which this defect can usually be eliminated:

First, cut the coil in two; this can, in most cases, be best done on the back end of the armature, as at *x*, in coil 7. This opens the short-circuit but leaves the coil open-circuited, which will have the same effect as that described in Fig. 1, Part 1. If the machine is started and run for a few minutes, a burnt spot will occur on the commutator

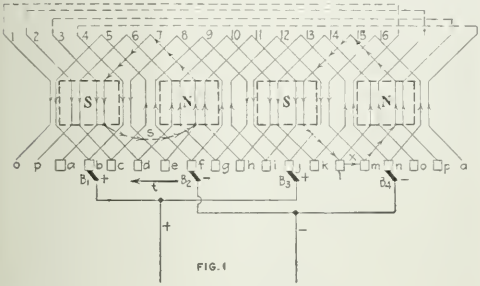


FIG. 1

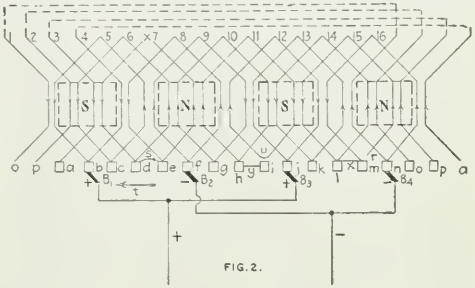

1 2 3 4 5 6 x7 8 9 10 11 12 13 14 15 16
S
N
S
N
s
u
r
o p a b c d e f g h i j k l m n o p a
+ B1
t
B2
+ B3
B4
+
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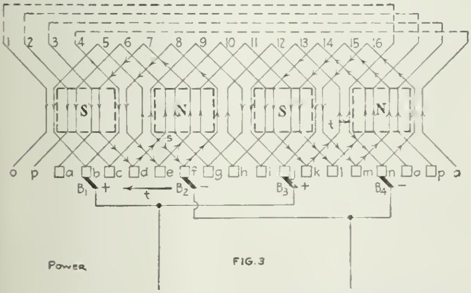
FIG. 2



Power

FIG. 3

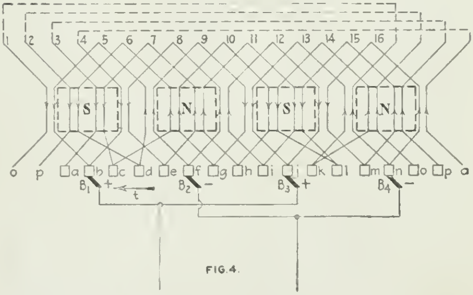


FIG. 4

Current Directions in Short-Circuited Armatures between the terminals of the defective coil, in this case between segments *d* and *e*. By connecting segments *d* and *e* together, as shown by the dotted line *s*, the open circuit is closed, and so far as the satisfactory operation of the machine is concerned, it will be the same as before the trouble occurred, and machines have been known to operate satisfactorily for years with just such a repair.

If the armature is series-wound, a better way of repairing the open circuit would be as described in Fig. 6, Part 1. In some cases the conductors in each half of the coil may be twisted or soldered together; this will close the open circuit and eliminate its repair at the commutator.

Second, a short between two of the commutator bars, as indicated at *x*, Fig. 1, will short-circuit coil 15, the arrow-heads indicating the closed circuit. This will cause heating of coil 15, although not to such an extent as the short-circuit in the coil itself. This short-circuit between commutator segments is usually caused by the mica between them carbonizing. The carbonized mica represents a large percentage of the total resistance in the coil circuit, which keeps the current down to a lower value than it would be if the coils were short-circuited copper to copper. This point of comparatively high resistance usually increases the temperature of the commutator segments between which the short-circuit occurs to such an extent that they force up higher than the rest, and, if not detected, the segments may rise up far enough to destroy the brushes. In one case that the writer can recall, the brushes knocked two segments out of the commutator when they were forced up higher than the rest, due to a short-circuit between the bars.

Trouble of this nature in most cases can easily be located and repaired by sawing down the mica between the commutator bars with a hacksaw blade, until the defective mica is all removed, then drive a piece of sheet mica into the defect and file the high bars down to a level with the rest of the commutator. If the defect cannot be repaired in this way, one of the coil leads may be removed from either one of the segments between which the fault is located as at *r*, Fig. 2, and the two segments may then be connected permanently together. This necessitates the loss of a good coil in the armature. To avoid the loss of the coil, both coil leads could be removed from either segment, the two leads connected together as shown at *u*, and the two segments between which the defect is located soldered together. This method is defective in that it doubles the potential between the segments *i* and *j*. If the insulation of the commutator is poor, this may cause another breakdown between these two segments, and on this account it may be better to leave the coil out of circuit entirely, as shown at *r*.

Third, a short-circuit may occur between the leads of two coils located in different parts of the armature, as at *s*, Fig. 3, or between the two coils in the same slot, as shown at *t*; in either case this short-circuits a group of coils, which will have the effect of a heavy overload on the machine. If in a generator, it will fail to generate, and if the fields are excited from an outside source, the prime mover will have difficulty in bringing the machine up to speed. If in a motor the machine will start with a jerk and will draw excessive current from the line, which will soon cause excessive heating in the starting device and will blow the fuse before many points of the starting resistance are cut out.

A test may be made for such a condition by exciting the fields from an outside source, and then turning the armature by hand. If there is a short-circuit between coils, as shown in Fig. 3, the armature will turn harder at some points of the revolution than others. The cause of this is that when the group of short-circuited coils are under the pole pieces, current is generated in them of a direction which opposes the turning effect applied to the armature. When the group is between the pole pieces, no current is set up in the coils and the armature requires less effort to turn it.

Cross-connected coils will cause serious sparking at the brushes. This is the fault of the individual who made the connections between the coils and commutator, and if the armature is carefully tested in the shop it should never get out in this condition. Fig. 4 illustrates two ways in which this mistake may occur. At segments *c* and *d*, the two leads to each commutator segment are shown interchanged, while terminals of coil 14 are shown reversed at *k* and *l*. The first will cause sparking at the brushes only, while the second also causes local currents to flow in the armature, which will cause heating.

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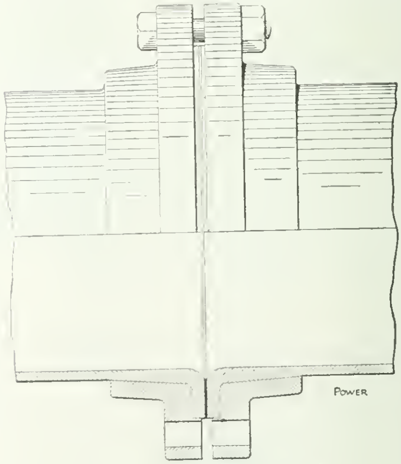
Improved Reinforced Van Stone Joint

A type of Van Stone joint, known for a number of years as the improved reinforced lap joint, is made by spot welding a collar to the end of the pipe, which is then flanged.



Reinforced Van-Stone Joint

After flanging, the joint is faced on the front, edge and back and turned on a regular taper to the end of the collar to fit a correspondingly tapered bored flange. The matching is done so that a neat fit is obtained between the pipe joint and the flange.

This joint gives about one and a half times the thickness of full-weight pipe on the face and double the thickness of the pipe through the curve. The joint, see illustration, is manufactured by W. K. Mitchell & Co., Inc., Twenty-ninth and Ellsworth Streets, Philadelphia, Penn.

Editorials

Outward Appearances

Clean paint and brightly polished metals do not make an engine run any better. No more does a white tongue nor a yellow complexion cause sickness, but where these are seen they are evidences of something wrong somewhere that does result in illness. We are admonished not to judge by outward appearances, but there are exceptions to this rule when it is decidedly in order to ignore such advice.

While the neat appearance of a plant proves nothing of the efficiency and economy of its equipment, it is a fairly safe index of the character of the engineer in charge. While "clothes do not make the man," they are an important means of arriving at some idea of him where circumstances may not afford any better knowledge. The right kind of man usually pays just enough attention to his dress and no more. If he is overdressed, it is as much a mark of a lack of desirable qualities as if he is slovenly dressed.

So, too, in the engine room. The engineer who pays too much attention to the looks of his machinery has not time enough or does not think deeply enough to keep the wastes and leaks out of the operating expenses. But, whoever knew an engineer who let dirt and rust accumulate in out-of-the-way places to bother about indicator diagrams or flue-gas analyses?

Carelessness of the outward appearances almost invariably extends to everything else with which the individual has to do.

Safety Factors

There appears on another page of this issue an abstract of the memorandum of the chief engineer of the Manchester Steam Users' Association for 1913, in which is described a practical method of obtaining the fatigue limit or true elastic limit of a material.

As has been before pointed out in these columns, the factor of safety is often erroneously referred to as a "factor of ignorance," when, for the most part, it is not used to cover any really unknown conditions with regard to the strength of the material to which it is applied, but to cover the uncertainty as regards the fatigue limit or true elastic limit, which is the logical measure of the ability of a material to stand repeated applications of a given load. Heretofore there has been no practical way by which the true elastic limit could be really obtained, and since the ultimate strength was a property that gave fairly uniform results with the usual test methods employed, it has been used as a measure by which the safe load was estimated, the correct safety factor to be applied to this measure being determined by experience.

With a practical method for determining the true elastic limit available, the methods of design and selection of material may be radically changed, and the factor of safety required in many cases could be reduced to a very small figure, for often the estimation of the true values of the applied stresses can be made with considerable precision.

What is more important than to be able safely to reduce the safety factor required, as may result from the methods of testing discovered by Mr. Strohmeyer, is the determination of a coefficient for each material by the formula which he derives. With this coefficient known, it can be predicted whether a material will stand few or many repeated stresses beyond its elastic limit, and since in some structures it is practically impossible to provide against such excess stress, the determination of this coefficient for the material to be selected for such parts is a matter of utmost importance. This is clearly demonstrated in the example selected to illustrate the influence of the coefficient, for with two metals not greatly at variance as to the true elastic limit, one was shown to be immensely superior when subjected to stresses beyond this point. Mr. Strohmeyer has attacked the problem of obtaining the true elastic limit in an original manner, and his test may become as general and as useful as that by which the ultimate tensile strength is determined.

Engineering Salesmanship

"Having two boilers, each carrying sixty pounds pressure, it will not be necessary to make any changes in the boiler plant as this engine will operate economically on one hundred and twenty pounds pressure." This contention (about as sound as the claim that two horses can run faster than one) was made to an engineer by a young salesman of steam engines.

The management was considering the installation of an engine-generator unit for light and power, but as the maximum pressure allowed on the boilers was only sixty pounds, the steam being used for heating and sterilizing, the idea was abandoned because a lack of funds forbade the purchase of new boilers. This difficulty did not appear insurmountable to the young man, as shown by the information he volunteered.

All of us on numerous occasions have been entertained by handsome, well groomed salesmen, massaged, manicured and full of "selling talk," "talking points" and superlatives to the extent of being tiresome, but their knowledge of the practical working of the apparatus they were trying to sell was not what it should be. Salesmen who visit a Turkish bath before calling on a prospect may be necessary in some lines, say face-powder and perfumes, but not to sell steam specialties. Who would not prefer to talk with a salesman who looked as well as talked as though he could install and then operate the thing he sold?

Inspired by the question, "Why do not more engineers become salesmen?" a certain competent engineer answered a number of advertisements for salesmen of steam specialties. In his letters he attempted no flourishes, confining himself to plain facts and frankly stating that he had had no experience in salesmanship. Nearly all his letters were ignored, or at least were not answered. One reply was a polite rejection on account of his inexperience, and one was favorable.

To make the average engineer an acceptable salesman it would seem necessary that he somehow acquire selling experience (how to get it without being given the first opportunity to try is a bit obscure); then so improve his personal appearance as to make a good "front," and lastly, study how to properly present his goods. Many an article has been sold, not because of any particular merit nor because it was really wanted, but because the buyer was "talked into" buying.

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The Kilowatt and the Horsepower

The Bureau of Standards has got out a second edition of its pamphlet dealing with the relation of the kilowatt to the horsepower. It has adopted 746 watts as the standard horsepower. When this was first proposed, we nodded approval, but this apparently simple simplification involves the upsetting or the establishment of another standard, the desirability of accommodating which to this specific and not overwhelmingly important case may well be questioned.

The watt is the metric or C. G. S. (centimeter-gram-second) unit of power: ten million ergs per second. The erg is the C. G. S. unit of energy; one dyne-centimeter—i.e., a force of one dyne exerted through the distance of one centimeter. The dyne is the C. G. S. unit of force, and is that force which, exerted for one second upon a mass of one gram, will give it a velocity of one centimeter per second. The gram is the metric unit of mass equivalent to that of a standard weight kept at the International Bureau of Standards near Paris and intended to be equal to that of a cubic centimeter of pure water weighed in a vacuum at its maximum density. The centimeter is the one-hundredth part of the length of the standard meter, that of a bar kept at the same place and intended to be the ten-millionth part of the distance from the equator to the north pole measured on an arc of a meridian.

Our unit of power is the horsepower, 33,000 foot-pounds per minute. The foot-pound is our unit of energy. The only legal definition of the foot in the United States is an act of Congress of July 28, 1866, fixing the relation of the inch to the meter as 39.37 inches. We have no legalized inch, foot or yard except as they are derived from the standard meter in accordance with the ratio so established. In England the meter is legalized as 39.370113 inches, so that the English inch, foot and yard are slightly different from ours. We have no legalized unit of pressure or force comparable with the metric dyne except the little-used poundal, the force which acting for one second on a mass of one pound will give it a velocity of one foot per second. We usually measure pressures in pounds, but what is a pound of force? A pound weight might be thought to exert a pound of force upon the weight pan of the balance in which it is used or upon a cord with which it is suspended; but this force will be different at different places because the earth attracts the weight with different degrees of force at different latitudes and elevations. It has been usual therefore, although so far as we know there is no legal authority for it, to consider the pound, when used as a unit of force, as that force with which the earth attracts a standard pound weight at latitude 45 and at sea level. All of the modern steam tables are computed upon this basis.

Using this established value of the pound as a unit of force and the legalized value of the foot, a horsepower of 33,000 foot-pounds per minute equals 745.65 watts, and it is as impossible to change this relation by any decree as it is to make the ratio of the circumference to the diameter of a circle 3.14 by passing a law to that effect.

The only way to make the ratio 746, assuming the value of the watt to be fixed, would be to change the value of one of the factors of the horsepower. To change 33,000 to the awkward, inexact value 33,015.49 would be to incur more trouble than we would be avoiding. It might be done by changing the legal value of the meter in inches to 39.3515, which would make the legal foot less than six one-thousandths of an inch longer than the present; but this might be important when the larger derivatives of the foot, as acres and miles, are concerned. The only other way is to change the accepted value of the pound as a unit of force, and this is what the Bureau does, using as that value the force with which the earth attracts a standard pound weight at latitude 50 instead of at latitude 45.

Steam of a certain pressure acts in an engine, and from this pressure its horsepower is determined. To be consistent with the new practice of the Bureau, we must measure this pressure in the new units. But the steam tables give us the physical properties of steam measured by the old 45-degree unit. Must we make the steam tables over?

This discussion is all academic. Everybody uses 746 for ordinary calculations, just as they use 778 foot-pounds for the mechanical equivalent of heat, and the case is difficult to imagine where it would make any practical difference whether a horsepower were legally equivalent to 746 or 745.65 watts.

But there is a phase of this discussion which is of practical interest. It has been often said, and rightly so, that the horsepower is an irrational, archaic unit, and ought to be abandoned in favor of the kilowatt. The Bureau in the circular under review repeats the argument and reiterates the recommendation. But how shall we, with the dimensions of our engines in feet and inches and with our pressure in pounds per square inch, conveniently compute their power in kilowatts? Surely not by computing the horsepower and multiplying by 0.746. That is no way to get rid of the horsepower. A kilowatt is 44,256.7 foot-pounds per minute. The formulas stand

$$hp. = \frac{PLAN}{33,000} \qquad kw. = \frac{PLAN}{44,256.7}$$

If there is going to be any change in our units either of pressure, length or area, let it be such as to make the divisor for the kilowatt as simple as that for the horsepower. Then the newer and more rational unit will rapidly replace the old. So far as its use as a unit of boiler capacity is concerned, the horsepower has no excuse for continued existence and should have been abandoned years ago. The present practice of running boilers over rating and the improved efficiency of engines and turbines increase the discrepancy between the capacity of a boiler rated in horsepower and the horsepower got out of it in service, and are additional reasons for the abandonment of an unscientific and unsuitable unit.

Correspondence

Records to Detect Coating of Turbine Blades

Turbine operators keep such data as load, steam pressure, vacuum, pressure of the various stages, etc. In view of an operating condition in some plants, where scale-forming matter contained in the feed water coats the blades of the turbine to such an extent as to seriously interfere with the efficiency as well as to impose undue end thrust on the unit, a continuous record should be kept of the position of the inlet valves at the various loads.

This can be easily noted with the larger types of impulse turbines as they have many inlet valves, the number in service varying as load conditions change. The operator could note the number open or partially open and a comparison checked over a year's run of the valves required for any load will be an unfailing indication as to the condition of the turbine blades.

John F. Hurst.

Louisville, Ky.

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Does Oil Attack the Engine Cylinders?

The inquiry of B. F. Mayer on the above subject, page 537, Oct. 13 issue, is interesting. The writer has had analyses made of the cylinder oils in use in various plants, and while they include most of the usual brands of oils, in no one analysis has more than a trace of acid been shown. It is hard to believe that any reputable oil dealer would attempt to market a standard or special grade that contains acid.

Mr. Mayer says that the engines are triple expansion, each having two large low-pressure cylinders, and that the vacuum is 27 in., but he does not state whether the trouble is with all the cylinders, although it can be inferred that it is with the low-pressure ones only.

Every engineer accustomed to starting up new machinery realizes the importance of flooding the bearing surfaces with oil until they have become smooth and polished. In the case of a large horizontal Corliss engine, not only must the valves and the packing rings in the cylinder be lubricated, but also the bottom of the cylinder, which in the absence of a tail rod has to carry the entire weight of the piston and the piston rod. A further reason for the use of a liberal amount of oil in the early stages of operation is that, no matter how carefully the steam pipes and passages are blown out before starting, some dirt will remain. When this dirt becomes loosened by the expansion and contraction of the pipe and by the pulsating movement of the steam, it is carried to the cylinders. Therefore, unless the oil is used very freely, trouble will often result.

While there are many triple-expansion engines the low-pressure cylinders of which take steam at about atmospheric pressure and exhaust into the high vacuum that can be maintained (27 to 28 in.), and operate successfully and present no difficulties in lubrication, yet occasionally trouble such as Mr. Mayer describes is met.

Assuming that the engines have been built by a reputable company and represent its standard practice in materials and workmanship, the question of hardness or softness of the iron can be eliminated, at least for the time being. It may also be assumed that the engines are in alignment, with no distortion due to expansion.

With the use of a suitable oil and the correct introduction of it into the cylinders, there should be no difficulty in lubricating them. The amount necessary would have to be determined by experiment and trial extending over considerable time. Regardless of how much oil is used, it is difficult to understand how it could attack the cast iron.

If the oil contains acid it should not be used. If one is sure the oil is all right and the cutting occurs, it is then important to determine whether it takes place continually or at intervals of from one to several weeks or months. If the latter is the case, the trouble is usually because of impurities in the steam. Such impurities may be due to the nature of the feed water alone or to a boiler compound or combination of both. Analyses of the feed water and of the water from the traps taken under normal conditions may not show anything wrong, but analyses are seldom made during an emergency or at abnormal conditions of operation.

Triple-expansion engines of this type are difficult to lubricate, owing to the low pressures and temperatures prevailing—initial pressure about 15 lb. absolute and temperature 212 deg.; exhaust pressure about 1 lb. absolute and temperature about 100 deg. F. in the low-pressure cylinder. Any impairment of the quality of the oil or interruption of feed for a long interval usually results in cutting the bearing surfaces.

W. Hamilton.

Troy, N. Y.

It is rather difficult to prescribe "absent treatment" for Mr. Mayer's case, but having had trouble with cutting cylinders, the following may be worth as much in his case as it was in mine:

If the piston rings and bull ring are sharp and square on the edges, they may be scraping the oil off the cylinder surfaces and cutting them. The remedy is to slightly chamfer the edges of all the rings. This allows the oil to work under them and lubricate properly and adequately.

It would be interesting to know just what Mr. Mayer's trouble is, if he finds out.

William N. Wing.

Brooklyn, N. Y.

This rapid cutting of the cylinder walls, described by Mr. Mayer as being of "soft, coarse gray iron," is more likely to be due to excessively tight packing rings with sharp edges than to acid-bearing oil.

A glance at the cylinder bore would tell if the trouble is due to acid; if so, the cylinder would show a peculiarly pitted surface. When viewed through even a low-powered microscope, the attacked surface has the appearance of being etched. The pitting effect is never uniform and tends to spread like a fern. Furthermore, the action is most apparent where the temperature is highest, since an acid is more active when hot.

Mention is made of a high vacuum. This would tend to decrease the chemical effect of acid since the higher the vacuum the lower the corresponding temperature. That the high and intermediate cylinders are made of closer grained iron would not make them immune to acid, for acid attacks a hard surface quite readily; the "etching" effect is of a finer pattern than in the case of a coarse-grained iron.

It is quite true, as Mr. Mayer has been advised, that acid will penetrate beyond the surface. Cylinders are sometimes pickled in acid at the foundry. When being bored, even weeks after pickling, the acid will dampen the metal at any spongy place and apparently ooze to the surface under the cutting action of the boring tool.

I have successfully used a mixture of one part cylinder oil to one part fine flake graphite to prevent cutting valves and piston rings, and I would recommend this to Mr. Mayer. The oil should be heated before adding the flake graphite.

E. Hurst.

Montour Falls, N. Y.

Cooling Effect of Evaporation

An article under the above heading on p. 512, Oct. 6, explained clearly why liquids evaporate more rapidly when a current of air is passed over them. It might have gone a little further and told how the evaporation of the ether freezes the water—i.e., when a pound of ether is evaporated at atmospheric pressure, 162.8 B.t.u. are required to effect this change. This is called the latent heat of vaporization and is that which is required to change the condition of the molecules; it does not appear as sensible heat. If the vapor is again condensed or compressed, however, each pound of ether would again give up its 162.8 B.t.u. of latent heat.

Where evaporation is produced, as described, by a current of air, the ether receives very little heat from the air stream, but heat must be supplied before the liquid can evaporate and it is simply drawn from the remaining ether, which in turn draws heat from the water. This lowers the temperature of the water to the freezing point.

Here again latent heat is encountered, for it is not sufficient simply to lower the temperature of the water to the freezing point, as after reaching that point there must be extracted for each pound of water 144 B.t.u. before the water becomes ice.

Of course, the amount of water used in the experiment is comparatively small, so that the total heat to be withdrawn is a very small quantity, but all of the ether that is not evaporated is lowered to a temperature at least slightly below the freezing point of water so that the experiment succeeds best when only a small amount of ether is taken.

P. L. Weimer.

Gary, Ind.

Queer Compressor Diagrams

In his letter, in the Oct. 13 issue, p. 541, Mr. Crawford says in regard to the diagram, Fig. 2: "It indicates that the compressor is in good condition."

I differ with him, for something seems wrong with the discharge valve. By analyzing Fig. 1, which is a reproduction of the diagram, this is made plain. Starting at *A*, the piston compresses the gas to *B*, where the discharge valve opens and lets the gas escape to the condenser. The pressure then drops to *C*, where the discharge valve closes and it is again raised to *D*, when the discharge valve again opens. The pressure then falls to *E*, which should be the condenser pressure. It seems impossible for the gas to leave the cylinder at a lower pressure than the condenser pressure, and such being the case, line *F* is the condenser pressure and the machine is pumping against an excess pressure from the line *F* to *H*. It also seems that the spring on the suction valve is too tight as shown by the wavy line at *G*. Of course, it is impossible to tell much about ammonia diagrams unless the theoretical expansion curves are drawn on them.

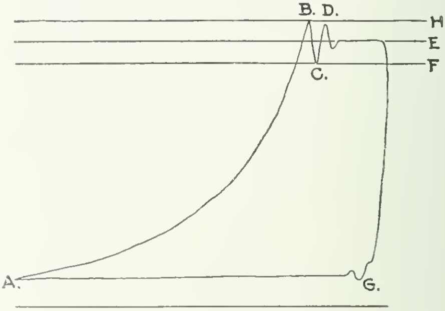


FIG. 1

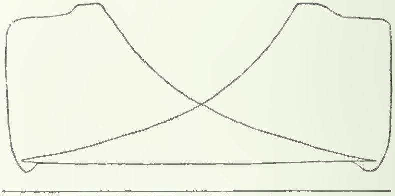


FIG. 2

Ammonia Compressor Diagrams

I have drawn the adiabatic and isothermal curves on two diagrams that looked excellent, but the curves showed the discharge valves to be leaking badly. An ammonia compressor diagram does not seem to be as well understood by the average engineer as are those from steam engines. As an example, Fig. 2 is a reproduction of a diagram shown in the advertisement of a manufacturer of a double acting compressor. The figure shows that both the discharge and suction valves stick. Two or three hours' work on these valves would have eliminated this trouble, and the humps on the diagrams would have been absent. A small amount of reëxpansion is shown, considering that long pipes were used. This is a wrong way to connect up the indicator as the long pipes make quite a difference in the reëxpansion shown on the diagram over that which a short pipe connection and a single diagram show. These people evidently did not understand this or they would not have used this diagram for advertising purposes.

Perry Losh.

Muncie, Ind.

Test of Lentz Engine

In the issue of May 28, there was published a discussion by Mr. Rosenzweig of the tests which I made on a simple noncondensing Lentz engine. For personal reasons, I hesitated to reply at the time, but it now happens that somewhat similar and carefully conducted tests, made in a Western state by a well qualified engineer, are being prepared for publication. Since in these tests the temperature of the superheated steam supplied to the engine was measured, as in my test, with a carefully calibrated mercury thermometer, it seems necessary to state the case a little more fully.

Mr. Rosenzweig used as a basis for his computations the temperature of the steam in the exhaust pipe, and calculated that, if a theoretically adiabatic expansion is assumed, the actual superheat would be nearly 100 degrees higher than that observed and reported. There are several reasons why this assumption is improbable. In the first place, the temperatures in the exhaust pipe were observed merely as an afterthought. The thermometer used was put in the exhaust pipe by one of the testers for his own information and no precautions were taken to insure the accuracy of these observations. Furthermore, the thermometer was not calibrated and the thermometer well used at this point was very shallow. These facts should make any discussion from this basis of doubtful value.

It is improbable that the carefully calibrated thermometer, corrected for stem exposure, which was used for measuring the initial temperature of the steam could have been in error anything like 100 degrees, and it is admitted by Mr. Rosenzweig that there is no doubt whatever as to the accuracy of observing and recording this temperature. He also assumes that the expansion is adiabatic. In an engine having no steam jacketing on the cylinder, of moderate speed, and using steam of very high temperature, it is obvious that the expansion does not follow closely the adiabatic.

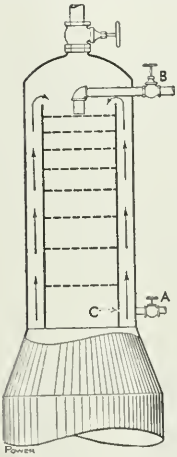
As regards the argument itself, that a mercury thermometer is unsuitable for measuring the temperature of superheated steam, the error is likely to be of much more significance in obtaining the temperature in the exhaust pipe than that of the highly superheated steam. It is well known that the temperature of steam of from 0 to 20 degrees superheat is difficult to measure, as it is almost impossible to eliminate all the moisture present in superheated steam of this low degree.* At these low degrees of superheat, the steam is usually more or less stratified, some wet steam being present. The latter lies nearer to the bottom of the pipe than that which is superheated, and not infrequently water is found either entrained or in a liquid mass in the bottom of the pipe, where it remains unevaporated by the flow of superheated steam over it. Undoubtedly these were the conditions existing in the exhaust pipe of the Lentz engine tested, hence they should have little significance, even if the observations of the steam temperature in the exhaust pipe had been made with an accurate or properly calibrated thermometer.

J. A. Moyer.

State College. Penn.

Strong Aqua Short-Circuit in Analyzer

Recently I had occasion to renew the steam coils in a high-pressure-steam ammonia generator in an absorption plant. After the unit had been dismantled, a friend suggested that I change the point of entering the strong aqua from the pump to the generator, to allow the pump to discharge directly on the top of the analyzer pans instead of at the base of them. This would make it necessary for the aqua to come to the top before it could start on its downward course over the analyzer pans. The reason for suggesting the change was to prevent short-circuiting the strong aqua through a part of the analyzer pans. The sketch shows what changes were made.



Analyzer for Ammonia Generator

Valve *A* is where the strong aqua was formerly discharged, and the arrows indicate the path it took after entering the generator at the base of the analyzer. This valve was blanked off and a hole drilled and tapped into the shell for the line *B*, the shell at this point being $2\frac{1}{8}$ in. thick. The hole was tapped out $1\frac{1}{16}$ in. from both inside and outside the shell, to enable a nipple to be screwed into the shell from both sides. A short nipple with valve *B* was screwed into the shell from the outside, to which the aqua pump discharge was connected, and a nipple long enough to bring an ell to the center of the shell was screwed into a hole on the inside. The ell turned down with a nipple screwed into it, terminating within 4 in. of the bottom of the top analyzer pan as shown. The ammonia-gas outlet is, of course, at the top of the generator and is controlled by a valve.

Before making this change, it was almost impossible to keep the joints between the pans tight, and they showed that the aqua was short-circuiting through them and passing down onto the steam coils.

A half-inch hole was drilled in the analyzer base at *C*, to prevent aqua getting over the pans and trapping in the bottom of the analyzer. The manufacturers of these generators have adopted this method of entering the strong aqua to the analyzer in their later generators, but the generator referred to in this article was one which was built several years ago.

The principal requirement in making such a change is to get a good thread when tapping out the hole after it has been drilled.

C. T. Baker.

Jacksonville, Fla.

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*See "Steam Turbines," by J. A. Moyer, second edition, pp. 261 and 262.

Engineers' Study Course

Problems in Power-Plant Design—V

LAYOUT OF THE POWER HOUSE

In laying out the power house, no attempt will be made to go into details of construction. The idea is to study the arrangement of the different parts of the equipment with special reference to convenience and economy of operation, and to furnish diagrams and dimensions from which the architect may prepare designs for the building. The sketches of boiler settings, etc., are such as would be given to the head draftsman from which to work out the detail drawings.

BOILER SETTINGS

The first step in laying out the power house is to determine the space required by the boilers, and simple diagrams of the settings are prepared for this purpose. It seems a good arrangement, in the present case, to set the boilers in batteries of three each, and Figs. 1 and 2 have been worked out on this basis.

Heavy "Hartford" settings have been used with the outer or supporting walls 30 in. thick, consisting of an inner wall 16 in. thick, a 2-in. air space and a 12-in. outer wall. The division walls between the furnaces are 32 in. thick, the bridge-wall 28 in., and the rear walls 26 in., with a 2-in. air space. Table 1 gives overall dimensions for boilers of different diameters with heavy settings for power work.

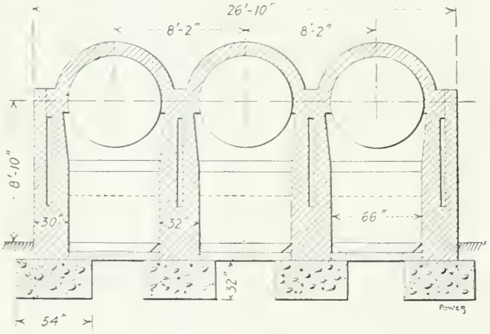


FIG. 1. SECTION THROUGH BATTERY OF THREE BOILERS

TABLE 1—DIMENSIONS OF BOILER SETTINGS

No. of Boilers in Battery	Diameter of Boiler, In. 54	60	66	72
Width of setting, 1 boiler..	9′ 0″	9′ 6″	10′ 0″	10′ 6″
Width of setting, 2 boiler..	15′ 8″	16′ 8″	17′ 8″	18′ 8″
Width of setting, 3 boiler..	22′ 4″	23′ 10″	25′ 4″	26′ 10″
Width of setting, 4 boiler..	29′ 0″	31′ 0″	33′ 0″	35′ 0″

The total length of the setting is equal to the length of the tubes plus 4 ft. 2 in. for the diameters in Table 1. If the "gallows frame" support is employed, lighter walls may be used. With columns between each boiler, the girders for 6x16-ft. boilers should be made up of two 9-in. channels, with suspension rods 1½ in. in diameter. If wrought-iron pipe columns are used, they should be 9 in. in diameter and the lower ends should be embedded from one-fourth to one-third their length in heavy foundations of concrete.

FURNACE

This is made of good height for burning bituminous coal. If mechanical stokers are employed the furnace details should be furnished by the makers and all dimensions obtained from them. The grate area is found by the formula

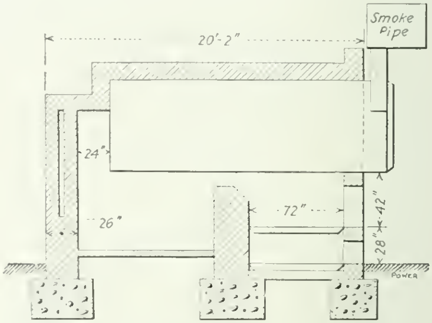


FIG. 2. LONGITUDINAL SECTION OF SETTING

$$S = \frac{hp. \times 34.5}{E \times C}$$

in which

S = Grate area in square feet;
E = Pounds of water evaporated per pound of coal;
C = Pounds of coal burned per square foot of grate per hour.

With natural draft, C should equal at least 15 lb.; and with clean tubes and skillful firing an evaporation of 9 lb. of steam per pound of coal should be obtained. Table 2 is computed from the above formula for different values of E and C, covering ordinary conditions of power-plant work, and gives the square feet of grate surface per horsepower for different combinations.

TABLE 2—GRATE SURFACE PER HORSEPOWER

Values of C	Values of E 12 Lb.	15 Lb.	20 Lb.
10	0.28	0.23	0.17
9	0.32	0.25	0.19
8	0.36	0.29	0.22

Assuming values of 9 and 15 for C and E, respectively, for the present case

$$120 \times 0.25 = 30 \ sq.ft.$$

of grate area should be furnished for each boiler. The dimensions given on the drawings are

$$5\tfrac{1}{2} \times 6 = 33 \ sq.ft.$$

The main smoke pipe may be proportioned on a basis of 1 sq.ft. area to 7 sq.ft. of grate, which for five boilers running at one time will call for

$$\frac{5 \times 30}{7} = 21.4 \ sq.ft.$$

This may be made 4 ft. wide by 6 ft. in height, which gives a flue on the side of safety. The extreme end of the flue may be made about 20 in. in height and increase uniformly to the boiler nearest the stack, the width being kept the same throughout. It should be made of No. 10 iron, on an angle-iron frame, and hung from the roof trusses. The uptakes from each boiler should be 12x60 in.

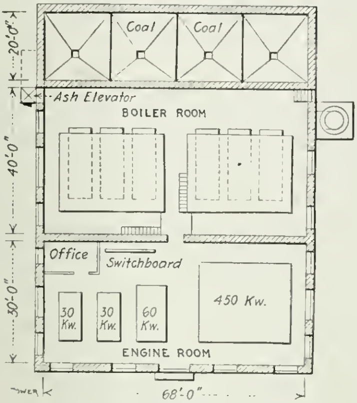


Fig. 3. General Arrangement of Boiler and Engine Rooms

Chimney

The required height of chimney will depend largely upon the kind of fuel to be burned and will vary from 120 ft. for slow-burning bituminous up to 150 ft. for buckwheat. For plants of 600 to 800 hp. and over, the chimney should not in general be less than 150 ft. in height, whatever the grade of fuel to be used. Assuming this height in the present case, we find from Kent's formula that a flue 5 ft. in diameter will be required.

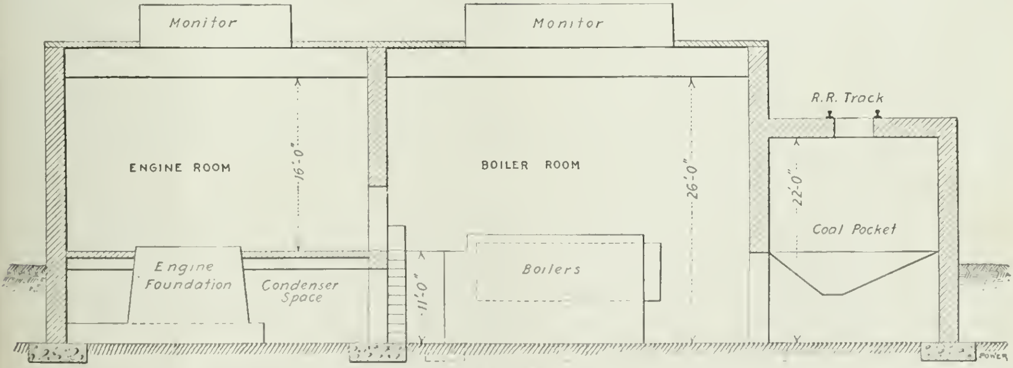


Fig. 4. Floor Levels and Grades in Power Plant

Boiler- and Engine-Room Dimensions

The general arrangement of the boiler and engine rooms is shown in Fig. 3. Ample space has been allowed around the boiler settings, giving a 4-ft. walk at each side and a central space between the two batteries of 6 ft. 4 in. A passageway 6 ft. in width has been provided at the rear, both central and rear passages being widened somewhat to allow for the iron stairways leading down from the engine room. A firing space of 14 ft. is allowed in front of the boilers which provides for drawing the tubes beneath the front of the coal bunker.

The overall spaces required by the different generating sets have been drawn in from catalog dimensions and a room 30x68 ft. seems to give ample space for all requirements. The different floor grades of the power house are shown in Fig. 4, which represents a longitudinal section. This arrangement, with the main engine-room floor above that of the boiler room, makes it possible to carry all exhaust piping beneath the floor and provides a space for condenser and pumps at the boiler-room level beneath that corner of the engine room occupied by the private office and switchboard. It is always desirable, if possible, to place the condenser at a lower level than the engine on account of drainage and simplicity of pipe connections.

This plan also makes it possible to enter the pipe tunnel easily with the heating main and to connect the main return with the receiving tank without providing a pit or trenches. The engine room is entered by two or three steps from outside grade. Besides the various generating sets, it contains the switchboard and a gageboard carrying a series of pressure gages connecting with various parts of the system, also an air compressor and storage tank for supplying air pressure for cleaning purposes around the engines and generators.

The boiler room is reached by two flights of iron stairs from a platform at the engine-room level. A separate entrance is also provided from outside near the chimney, as shown. The large window on the opposite side is removable, leaving an opening large enough for removing a boiler if desired. A traveling overhead crane should be provided of sufficient capacity for handling the boilers in case of renewal. The ash elevator at the left is of the conveyor type and arranged to discharge directly into a car standing upon the raised track over the coal bunker.

Coal Storage and Handling

For the storage of the coal the space required will depend upon the amount it is desired to keep on hand or have delivered at one time. Factors of this kind will vary with local conditions and must be decided upon in each particular case. In the present problem let us provide storage capacity for at least six weeks' supply for the maximum 600 boiler-horsepower.

Assuming four pounds of coal per horsepower per hour, eight hours run per day for six days per week will call for

$$\frac{4 \times 600 \times 8 \times 6 \times 6}{2000} = 345 \textit{ tons}$$

Assuming 35 cu.ft. of space per ton,

$$345 \times 35 = 12{,}075 \textit{ cu.ft.}$$

of storage space will be needed. Making the bunker of the dimensions shown in Figs. 3 and 4 will give the following capacity, allowing for the slope of the coal when dumped from the car:

$$20 \times 68 \times 9 = 12{,}240 \textit{ cu.ft.}$$

In the arrangement shown, the coal cars are run up an incline to the top of the bunker and their contents dumped through openings as indicated. The bottom of the bunker is provided with four chutes with sloping sides from which the coal is delivered into tram cars and brought to the boiler fronts for firing. If automatic stokers are used a special conveyor may be provided for delivering the coal directly into the hoppers, or an elevator and raised track may be so arranged that the contents of the tram cars may be dumped into the hoppers without shoveling. These are matters of detail to be worked out according to the amount of money available for equipment.

Foundation

The foundations for boilers, engines and chimney are important matters and should receive careful attention. In the case of heavy boiler settings for power work the foundations may be made from 20 to 24 in. wider than the brickwalls which they are to support if a solid earth footing is available. If this is not the case, the weight must be computed and the bearing area of the foundation made such that the load will not exceed the following limits per square foot: Soft clay, 1 ton; stiff clay, well packed sand and loam, 2 tons; coarse gravel, 8 tons.

In some cases, if the soil is of low-bearing power, a solid bed of concrete may be laid down for the boilers to rest upon. The depth should be from 2 to 4 ft., according to the size of boiler. What has already been said applies also to engine and chimney foundations.

With mud, silt or quicksand in a thin layer it may be possible to excavate to the gravel, clay or rock substratum and carry the foundations down to rest upon this. In the case of thick layers, piles should be driven on 2- to 2½-ft. centers and the tops cut off below the level of the surface water. A layer of concrete 2 or 3 ft. in thickness should be laid over the piles with their tops extending into it, and on top of this the regular foundation.

In computing the weight of a chimney the following figures may be taken: Granite masonry weighs from 150 to 170 lb. per cu.ft., and brickwork from 120 to 130 lb.

When there is any doubt as to the nature and carrying capacity of the soil an expert should be called in to fix a safe value before designing the foundation.

Line Loss—Conditions may readily occur in connection with wiring where the drop may not be sufficient to cause any difficulty in the operation of lamps or motors but if the loss over these wires is figured, it will be found advisable to use larger wire, as the interest on the increased cost of the wire will be less than the loss of power by the use of the smaller wire.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Science has proved that coal does not deteriorate in storage. But we have coal to burn. Can't some thoughtful scientist do something to ameliorate the condition of the egg? Its deterioration in storage is something fierce, not to say rotten.

⁂

"The governor went to pieces suddenly." This happened in several states recently. Well, when the "plant" outlives its usefulness, scrap it and get new apparatus—which has also been done in several recent instances. There are many "engineering" points in politics that stick out just like they do in our own field.

⁂

The newspapers have given wide vent to the foot-and-mouth disease among our cattle. This head-to-foot trouble give rise to the sweetly solemn thought that the disease probably had its origin in the thickhead who every time he opened his mouth he put his foot in it—and the complaint is more prevalent than is popularly supposed.

⁂

Know how to detect a liar? Easy! Put your finger on his pulse. If the blood pressure is unsteady, he's a liar—provided the osteopath had a steady pressure when she told this. A slap won't do it; grab the wrist between your fingers.

⁂

Here's another little shop kink the osteopathers are putting over: Disease is the father of bacteria rather than bacteria the cause of disease. Another variation of which was first, the egg or the hen?

⁂

Paper says Austria yearly sent to us 1,634,070 bushels of beans, and that soon there'll be a bean famine because of the war. How 'bout it, you New England engineers? Neutrality is all very well, but this is a blow below the belt that calls for reprisals.

⁂

The management says that the Panama-Pacific Exposition will open on time, which is Feb. 20, 1915. Fifty-six million dollars has been invested in it, a rather substantial evidence of faith in its success. Here's hoping that Science, Art and Industry will take their lead over the usual merry-go-round and popcorn shows that obtain at fairs.

⁂

We ask leave to print that a Los Angeles Prohibitionist has been elected to Congress, Our own personal leanings toward Prohibition do not actuate this announcement so much as that, believing in fairness, we think every party should have at least one representative in Washington.

⁂

Herewith the "Cincinnati Enquirer" is bluntly accused of exceeding bad taste. Under the title, "The Song of the Empty Growler," said paper prints a "poem" about a girl who worked in a boiler shop pounding rivets all day long "and she was very dry." She wishes she had a drink. The foreman rushes the said receptacle, drains its contents and hands the lady riveter the empty can. Then she sings—Say, isn't all this disgusting? In the first place, no boiler-shop foreman would be so impolite as to— We repeat, isn't this disgusting?

⁂

When we get going strong on our South American industrial campaign, will we again hear that cry about loose methods of crating and shipping? There's no use wrapping Orsat apparatus or electric meters in tissue paper, have 'em just precede a steam locomotive into the ship's hold—and expect the senors to be tickled with their purchase. If we don't know how, let's ask J. Bull or Billy Hohenzollern; goodness knows, they've been sending enough stuff down that way up to now.

⁂

Have a dim recollection that power plants once had chaps called oilers. Never see them mentioned in cold print these days. Oh, yes, he's the feller that polishes the brass and fills the lubricators. Mebbe if the engineers occasionally let him key-up, put a unit on the board or take the meter readings, or suchlike, he might from sheer gratitude write and tell us he's still a part of the force.

New York Combined Associations Hold Annual Ball

The thirteenth annual entertainment and reception of the combined associations of the N. A. S. E. of Manhattan, Bronx and Queens was held at Terrace Garden, New York City, on the evening of Nov. 7.

Among the invited guests were National President Frederick L. Ray, Louisville, Ky.; National Vice-President Walter H. Damon, Springfield, Mass.; National Secretary Fred W. Raven, Chicago, Ill.; National Treasurer Samuel B. Forse and National Trustee George W. Brownhill, Pittsburgh, Penn.; National Trustee Henry W. Mistele, Milwaukee, Wis., and Robert Larkin, business manager of "The National Engineer." There was also a number of past national presidents in attendance. Large delegations were present from Philadelphia, New Jersey and many of the New England cities.

The hall was tastefully decorated. An interesting vaudeville entertainment preceded the dance. It was impossible to complete the elaborate march planned by Floor Manager Frank Martin of Jenkins Bros., owing to the crowded condition of the hall, and for the same reason no picture was taken this year. Frantzen's thirty-piece orchestra furnished the music.

VISITING NATIONAL OFFICERS ENTERTAINED

On Friday evening Phœnix Association No. 24 held a special meeting for the reception of the national officers and guests. The several speeches were interspersed with entertainment by "The Bunch" and refreshments were served at intervals. Fred Felderman, president of the New York State Association, was the toastmaster.

A banquest was held on Saturday evening at 6 o'clock p.m., at which the national officers were the honored guests.

On Sunday afternoon there was an automobile trip to Long Beach, L. I., concluding with a dinner at the McAlpin Hotel, New York City. On Monday they attended the matinee performance at the New York Hippodrome after which the officers and guests boarded their trains for home.

The associations comprising the combination are Brotherhood No. 1; James Watts No. 7; Protective No. 23; Phœnix No. 24; Manhattan No. 25; German-American No. 29; Empire No. 32; Stevenson No. 44; Mott Haven No. 47; Insurance No. 56; Progressive No. 15.

⁂

Heating Boiler Explodes

On the afternoon of Oct. 26 a 30-in., six-section, cast-iron heating boiler exploded at the undertaking establishment of Costello Bros., 2324 West Lake St., Chicago. One man was killed and two were injured.

The boiler was about two years old and had been heating with hot water a two-story brick building 150 ft. long, and 30 ft. wide. This fall its location had been changed to the rear of the first floor and it was being remodeled to heat by steam under a maximum pressure of 10 lb. A steamfitter and helper had been working on the boiler and the piping the day of the accident. The boiler was supposed to be empty and a fire of kindling and paper had been started to test out the draft. The steamfitter had just gone upstairs to inspect the flue when the boiler let go, blowing a hole in the brick wall nearby and scattering the boiler over the floor. The four inner sections were badly broken while the two outside sections were only slightly damaged.

The cause of the explosion is not definitely known, but it is supposed that some water got into the boiler. After the explosion the valves on the steam supply and return mains were found open. One radiator had been connected and it is possible that it might have contained some water, as last season it formed part of a hot-water system. This water could have been forced back into the return pipe by pressure due to heating the air in the boiler The usual result of turning cold water into a hot cast-iron boiler followed.

On the work bench nearby lay a 1-in. safety valve. It had not been put in place on the boiler, nor could any evidence be found of a fusible plug. No permit had been sought from or granted by the city, so the boiler had not been inspected. In fact, the steamfitters had not completely finished their work. The damage to property was comparatively small. Including a new boiler, it should not exceed $500.

⁂

Location of Condensers—The hotwell of a barometric condenser should have a volume above the lower end of the discharge pipe equal at least to the combined volumes of the pipes above it. It will then be impossible for a slug of water to be drawn back into the exhaust pipe by the breaking of the water seal. The cone should be well above the head water, say, at least 3 ft., and 36 ft. above the hotwell overflow to give the most satisfactory results.

Recent Court Decisions

Digested by A. L. H. STREET

New York Labor Law Valid—The section of New York's Labor Law which requires employers to allow their men at least 24 hours rest in every week was lately sustained as being valid, as applied to employees of power companies, in the case of People vs. Niagara Falls Power Co., 149 "New York Supplement," 45.

Element of Damage in Condemning Land—In condemning land along a stream for water power purposes, the owner is entitled to an award covering depreciation in the market value of his remaining land caused by destruction by the improvement of a ferry affording him access to a particular market. (Georgia Supreme Court, Central Georgia Power Co. vs. Cornell, 81 "Southeastern Reporter," 882.)

Landlord's Obligation to Furnish Power—Under a lease of space in a building for light manufacturing purposes, requiring the landlord to furnish such power as he has available, the tenant is not entitled to recover damages for the landlord's failure to furnish power, resulting from an unavoidable breakdown of the power plant which occasioned only temporary cessation of power. (Chicago Embossed Moulding Co. vs. Max G. J. Hoffman, 184 Illinois Appellate Court Reports 617.)

Shares in Dam Privileges—The mere fact that three different parties who use a dam for power purposes contribute to the repair of it in certain proportions does not conclusively establish their right to share in the flow of the water impounded by the dam in the same proportions, according to a recent decision of the Appellate division of the New York Supreme Court, announced in the case of Lyon vs. Piser, 149 "New York Supplement," 197.

Safety of Fireman's Place of Work—In a recent suit involving a manufacturing company's liability for injury to its fireman, who fell into an ash pit while the boiler room was clouded by steam, it was held that the mere fact that the company permitted steam to escape into the room and allowed windows to remain broken out, so that cold air coming in contact with the steam condensed it, did not establish such negligent failure to provide a safe place of work for the fireman as rendered the company liable for the accident. Wajer vs. United States Brewing Co., 184 Illinois Appellate Court Reports 545.)

Oral License to Maintain Dam—Although it is a general rule that an interest in land must be granted by a written instrument, founded upon a valuable consideration, in order to be valid, the Florida Supreme Court decided the other day that where an owner of land has granted oral permission for the construction and maintenance of a dam or other improvement upon his land for the benefit of another, and the latter person has constructed such improvement at large expense, the license is irrevocable by the owner of the land or his successor, although nothing of value may have passed in consideration therefor. Albrecht vs. Drake Lumber Co., 65 "Southern Reporter," 98.)

Responsibility for Boiler Explosion—When an owner of a power plant expressly or impliedly invites persons to come upon the premises, he owes them a legal duty to use a reasonable degree of care to avoid their injury; but he is not an insurer of their safety. This legal principle has just been applied by the Kentucky Court of Appeals in a suit brought for the death of a customer at a mill, caused by explosion of a boiler. (Branham's Administrator vs. Buckley, 166 "Southwestern Reporter," 618). In affirming a judgment which denied the plaintiff's right to recover, although the plaintiff's evidence tended to show that the explosion resulted from permitting the water to run too low and by then forcing cold water into the boiler, the court said: "The evidence was conflicting but we cannot say that the verdict is flagrantly against the evidence The jury evidently felt some doubt as to the exact cause of the accident; and, having in mind the fact that there is a general disposition among men to preserve their property, and among operators of steam boilers to preserve their own lives, and that ordinarily these motives will secure that degree of care which the defendants were charged with under the law, the jury doubtless believed that the injuries to plaintiff's intestate were occasioned, not as the plaintiff contends, by negligence of the defendants, but rather by one of those unfortunate casualties which ordinary care and prudence will not always prevent"

PERSONALS

Frank Martin, formerly chief engineer with the American Hard Rubber Co., College Point, New York, has accepted the appointment as chief engineer with the Trenton & Mercer County Traction Corporation, Trenton, N. J.

Wolfgang Turnwald, formerly assistant to Prof. Johann Stumpf, of Charlottenburg, Germany, is now associated with the Stumpf Una-flow Engine Co., Syracuse, N. Y., in connection with the design of the Stumpf Una-flow engines.

De Witt Smith, formerly of Meriden, Conn., and more recently chief engineer of the Trenton & Mercer County Traction Corporation's plant, Trenton, N. J., has been appointed chief engineer of the Methodist Book Concern's building at 150 Fifth Ave., New York.

ENGINEERING AFFAIRS

Annual Dinner of Washington Society of Engineers—The annual dinner of the society will be held at Rauscher's, 1034 Connecticut Ave. N. W., on Thursday evening, Nov. 19, 1914, at 7.30 in the evening. W. A. McFarland is chairman of the banquet committee.

Second Annual Industrial Welfare and Efficiency Conference—The Department of Labor and Industry of the State of Pennsylvania is arranging for its second annual conference on industrial efficiency, welfare and safety at Harrisburg, Penn., Nov. 17, 18 and 19. The first part of the program will be in three general sections dealing with industrial betterment, compensation and the unemployment problem. During the remaining time it will be divided into four sections, safety, hygiene, welfare and fire-prevention. These sections will take up the specific problems already under consideration by the State Industrial Board or which need to be solved, and will present so far as possible practical information and suggestions which can be put into force in Pennsylvania for the advantage of both labor and industrial prosperity. All individuals interested in industrial affairs are invited to attend and take part in the proceedings. The first session will be called at 10 a.m., Tuesday, Nov. 17, in the State Capitol. In connection with the conference will be held an unusually effective safety welfare and efficiency exhibition, which opened on the morning of Nov. 16 and will close on the evening of Nov. 20.

NEW PUBLICATIONS

EXAMINATION OF LUBRICATING OILS. By Thomas B. Stillman. The Chemical Publishing Co., Easton, Penn. 9x6 in., 125 pages; cloth. Price, $1.25.

The rapid increase in the variety of machines, each with its own lubricating needs, not only complicates the methods of testing oils owing to a wider variety used, but it necessitates careful selection. This book gives in reasonably simple form, instructions for making the many tests which oils should be given. There are 116 illustrations and many tables and charts. Testing methods, specifications and laboratory report forms as adopted by various railroads and other large consumers of oil are given.

Most of the illustrations are pen-and-ink, and are well done, but many of the halftones are poor, although this is the only criticism we feel justified in making.

HEAT—By E. M. Shealy, assistant professor of steam engineering, University of Wisconsin. Published by McGraw-Hill Book Co., New York. Size, 6x9 in.; 262 pages; 110 illustrations. Cloth. Price, $2.

This is a textbook designed to supply students and practical engineers with the elementary knowledge essential to the study and understanding of heat-using machinery, such as the steam engine, the gas engine, the refrigerating machine and the air compressor.

The first part of the work is devoted to the fundamental laws relating to the nature, generation, transfer and transformation of heat with examples of practical application. The latter part of the text treats of the principles of heat and refrigerating machines and the relation of the laws of heat to those classes of machinery, sufficient treatment of each class being given for one who has had no experience with them to understand the relation of the laws, their principles and their operation. Chapter IV on transferring and measuring heat and the concluding chapter on house heating should be found of value to operating engineers who are interested in heating systems.

At the end of each chapter are about ten examination questions pertaining to subjects treated in the text, rendering the work of greater value to teachers and examiners and an aid to the reader in testing his knowledge of the subject. The illustrations, while not elaborate, have the merit of explicitness and completeness and the details are drawn with reasonable regard to actual proportions of the machinery and apparatus referred to without loss of emphasis.

A number of appropriate tables are quoted, such as coefficients of expansion, composition of fuels, heat given off by radiators, properties of steam, specific heats of substances, etc., making the work a good reference and textbook for operating engineers and firemen.

BOOKS RECEIVED

GEARING. By A. E. Ingham D. Van Nostrand Co., New York. Cloth; 181 pages, 5½x9 in.; illustrated; tables. Price, $2.50.

STEAM CHARTS. By F. O. Ellenwood. John Wiley & Sons, Inc., New York. Cloth; 91 pages, 7x10 in.; illustrated; tables. Price, $1.

COAL GAS RESIDUALS. By F. H. Wagner. McGraw-Hill Book Co., New York. Cloth; 179 pages; 6x9¼ in.; 44 illustrations; 31 tables; folding plates. Price, $2.

SHEET METAL WORKING. By F. Georgi and A. Schubert. D. Van Nostrand Co., New York. Cloth; 151 pages, 5½x8¾ in.; 125 illustrations; two folding plates Price, $3.

GRAPHIC METHODS FOR PRESENTING FACTS. By Willard C. Brinton. The "Engineering Magazine," New York. Cloth; 371 pages, 7x10¼ in.; 256 illustrations. Price, $4.

EXAMINATION OF LUBRICATING OILS. By Thomas B. Stillman. The Chemical Publishing Co., Easton, Penn. Cloth; 125 pages, 6x9 in.; 116 illustrations; tables. Price, $1.25.

GAS, GASOLINE AND OIL ENGINES. By G. D. Hiscox and Victor W. Page. The Norman W. Henley Publishing Co., New York. Cloth; 640 pages, 6x9¼ in.; 435 illustrations. Price, $2.50.

CATALOGS WANTED

Martin R. Carpenter, who has opened an office at Room 62, Pickering Bldg., Cincinnati, Ohio, as refrigerating engineer, would be glad to receive catalogs and price lists from manufacturers of ice and refrigerating machinery, etc.

NEW EQUIPMENT

ATLANTIC COAST STATES

Bids will be received until Nov. 21, by James Wood, Pres. Bd. of Mgrs., New York State Reformatory for Women, Bedford Hills, N. Y., for boiler house equipment, underground feeders and ground-lights at the Reformatory. Plans on file at 1224 Woolworth Bldg., New York, N. Y.

The City Council, Burlington, N. J., will change the motive power at the pumping station from steam to electricity at an estimated cost of $6000. Four pumps operated by electric motors will be installed. The Public Service Electric Co. will furnish the necessary energy.

Press reports state that the Adams Express Co. is considering the equipment of a power station at Second and I St., Washington, D. C. The cost will be about $15,000.

Plans are being prepared by F. L. Austin, 240 College St., Burlington, Vt., for the construction of an addition to the power house of the House of Correction, Rutland, Vt. J. E. Weeks, Rutland, is Chn. of the Com. in Charge.

A switchboard, costing $4000 will be installed at the plant of the Webster & Southbridge Gas & Electric Co., Southbridge, Mass. J. S. Shaw, Webster, is Mgr.

The capital stock of the United Illuminating Co., New Haven, Conn., has been increased by $500,000. Improvements will be made at the New Haven plant. R. A. Manwaring, New Haven, is Mgr.

SOUTHERN STATES

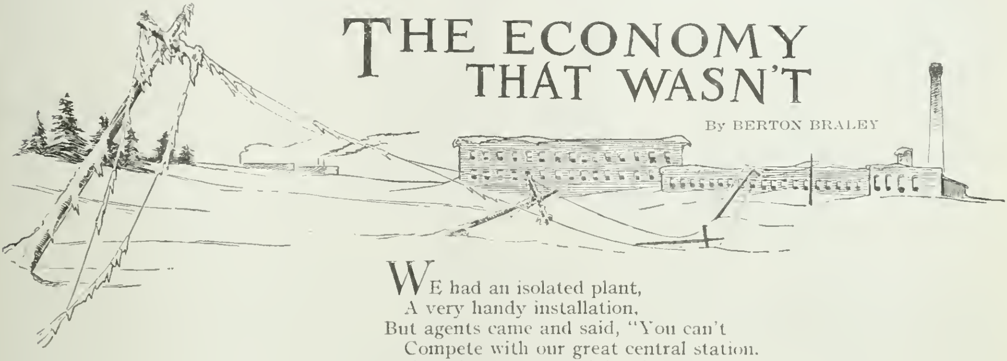
The City Council, West Monroe, La., contemplates installing a municipal light and power plant.

According to press reports, plans are being prepared by B. L. Baldwin & Co., Perin Bldg., Cincinnati, Ohio, for the construction of a power house for Rohen & Martin, at Maysville, Ky.

The Kellogg Toasted Corn Flakes Co., Battle Creek, Mich., is having plans prepared by W. J. Morehouse, 343 South Dear-

POWER

Vol. 40 NEW YORK, NOVEMBER 24, 1914 No. 21



THE ECONOMY THAT WASN'T

By BERTON BRALEY

WE had an isolated plant,
  A very handy installation,
But agents came and said, "You can't
  Compete with our great central station.
We'll sell you power mighty low,
  Much cheaper than you'll ever make it.
By facts and figures we can show
  How much you'll save if you will take it."

They washed our arguments away
  With floods of figures almost tidal,
Persuading us that it would pay
  To let our little plant lie idle.
They got us on their list, all right,
  The service proved most efficacious,
And oh we thought that we were bright
  And almost brilliantly sagacious.

And then—and then the power failed.
  "The lines were down," somewhere or other
And while we ranted and we railed
  We lost a day—and spoiled another.
We raved and 'phoned, and 'phoned and raved
  We talked both angrily and sweetly.
It mattered not how we behaved,
  The power still was dead—completely.

They got it going by and by
  And promised us no further worry,
But wintertime was drawing nigh
  When people don their garments furry.
We started up our winter fires
  To meet that chilly situation.
(It's hard to heat your plant with wires
  Connected with a power station).

Our coal bill proved almost as great
  As when our plant gave heat AND power,
And now we have to add the rate
  We pay per kilowatt per hour.
In fact we haven't saved a bit;
  The old plant made the better showing,
And we are going back to it
  The minute we can get it going!

West Breakwater Power Plant

By A. D. Williams

SYNOPSIS—A plant of unusual design installed by the Pennsylvania R.R. Co. to supply power for operating its ore dock and light and power to its yards and stations in the city of Cleveland.

* * *

In the design of this plant two classes of power were necessary in addition to both arc- and incandescent-lighting requirements: direct current at 250 volts for the operation of four 17-ton Hulett ore unloaders and a 15-ton ore bridge, and three-phase, 60-cycle, 220-volt power circuits for other requirements. Lighting is furnished from the direct-current supply to the unloaders, bridge and the power house; the yard is lighted from a mercury rectifier supplying 50 magnetite arc lamps, and 110-volt alternating current furnishes light to a machine and repair shop and supplements the yard lights.

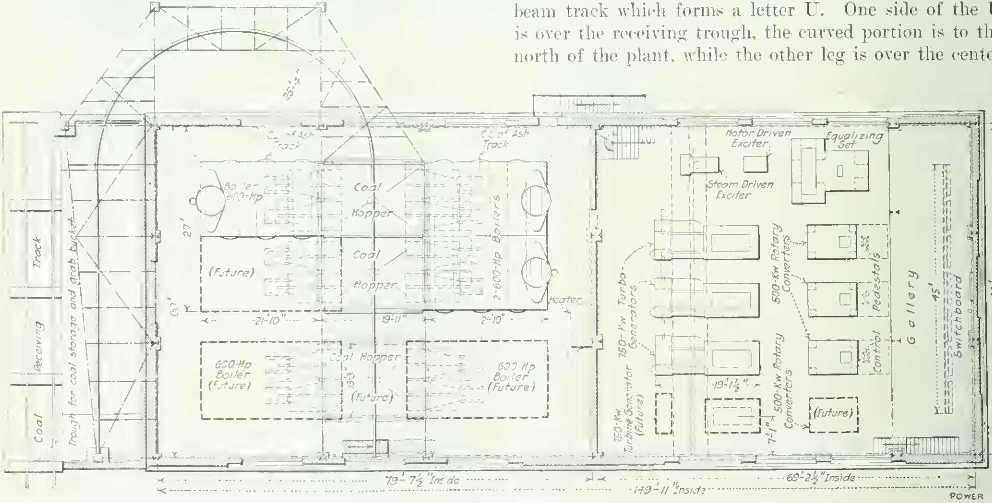


Fig. 1. Plan of Power Plant

Upon the west end of the new ore wharf of the company the plant is situated. The entire site of the wharf, covering about 40 acres, was originally under water, and it required about 1,000,000 cu.yd. of fill to bring the average grade up to about 4½ ft. above mean lake level. The basement floor excepting two trenches for railroad tracks, is six inches above this grade, or from two to six feet above the maximum and the minimum lake levels. The foundations for the building and machinery are carried by three hundred 30-ft. reinforced-concrete piles cast in vertical molds and after seasoning, driven through the fill. The basement structure, to the first-floor level, is of reinforced concrete and carries the boilers, the main machinery and the coal bunkers. The superstructure is of buff brick with cement copings, steel-framed windows and stone and cement trimmings, except the penthouse covering the coal bunkers and crusher, which is inclosed in cement mortar on metal lath.

The coal-handling arrangements are out of the ordinary. Coal is delivered in hopper-bottom cars which are run over and dumped into a track hopper about 60 ft. long on the west side of the building. The siding is 11 ft. above grade and extends along the side of the coal-receiving trough farthest from the building. This trough is so constructed that the coal will fall away from the receiving track into the portion of the trough covered by the monorail grab-bucket trolley, which runs on a track 72 ft. above grade; the bottom of the coal trough is 4 ft. below grade, making the total lift 76 ft. The trough gives a storage capacity of about 1500 tons, and two 100-ton bunkers serve each pair of boilers; provision has been made for a third bunker. The monorail coal trolley carries a three-ton grab-bucket and has a hoisting speed of 300 ft. per min. In order to prevent this heavy bucket from damaging the trough, an armor of old steel rails is placed in the bottom. The coal trolley runs on an I-beam track which forms a letter U. One side of the U is over the receiving trough, the curved portion is to the north of the plant, while the other leg is over the center of the boiler room (see Fig. 1). This track is supported on high skeleton steel masts outside of the building, and the portion over the boiler bunkers is in a penthouse protecting the trolley when not in use and also containing the motor-driven coal crusher.

This crusher is mounted upon a track and can be moved over either of the bunkers; it is fed through a hopper from the grab bucket and discharges by gravity into the bunker. These bunkers have hopper bottoms and outlets with gates arranged to feed the boilers on each side of the firing aisle through a breeches spout of square cross-section having inverted V-spreaders at their lower ends which cover the full length of the stoker hopper. At first, these breeches spouts clogged and required beating with a slicebar to bring down the coal. This was remedied by drilling holes, pointing upward, close to the points where the scaffolds seemed to form and tapping them. An air line was then run to each spout from the compressed-air supply and connected to a pipe nozzle inserted through the spout holes. A lever whistle valve with a cord led to a convenient location enables the fireman to break up any scaffolds that form, by the air blast with 100 lb. pressure. This method has proved satisfactory.

Each boiler is fired by a Roney stoker set in a 4-ft. "dutch oven" or coking arch. These stokers are driven by small Westinghouse engines supplied with steam from the auxiliary header. The exhaust from the engines is led to perforated pipes from which it blows into the fire bed on the stoker. Live steam is also brought to jets on these stokers and perforated water pipes for quenching the ashes are installed in each ashpit, along both sides and at the center wall. Fig. 8 shows a section through one of these stokers and the steam piping.

A feature of these stokers is their division into two sections with separate ashpits and doors for closing the ashpits and cutting down the draft when the boilers are banked. From the receiving hopper on the stoker the coal feeds down under a coking arch extending one-half the depth of the stoker grate. The rear half is covered by the regular arch gas baffle used in all Stirling boiler settings. Below the front portion of the grate there is a flat portion of the floor from which fine coal dropping through at this point may be recovered. The rear portion of the ashpit forms a chute, built in the

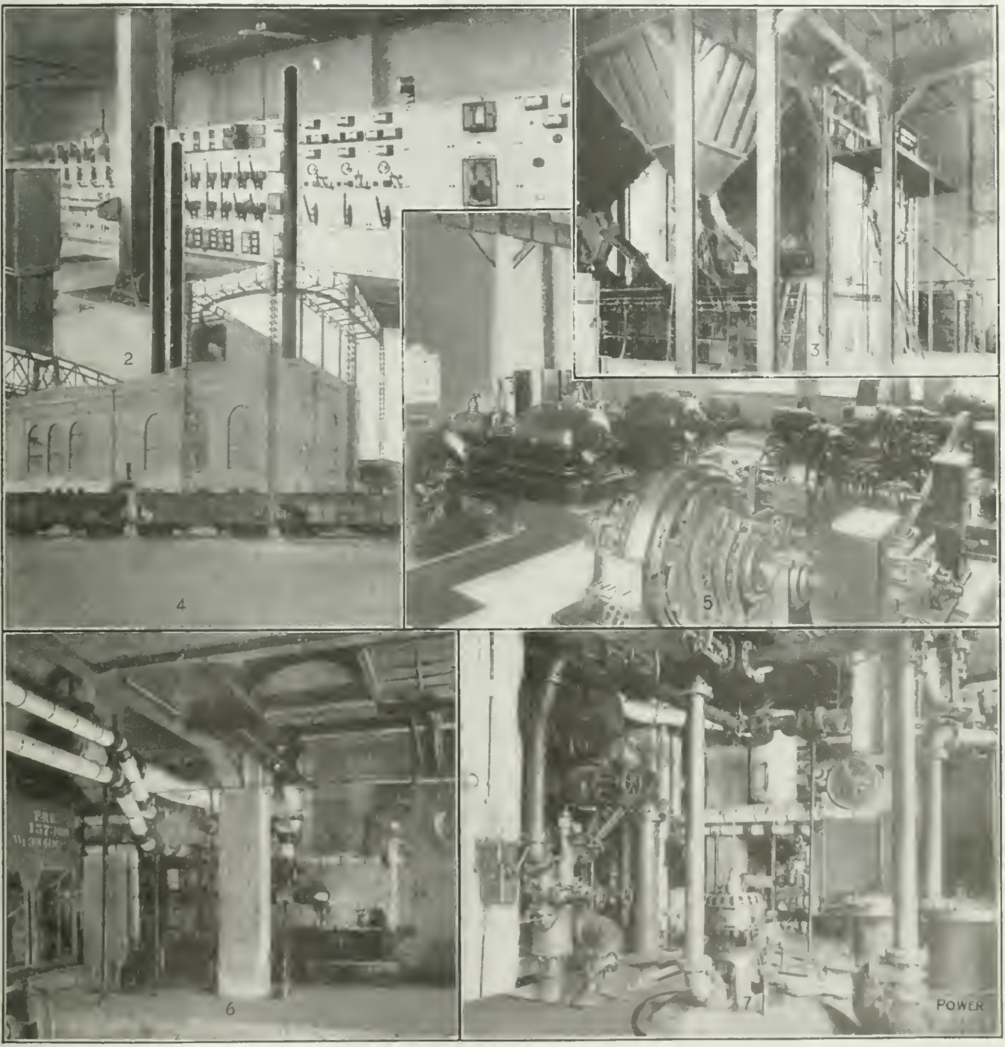


Fig. 2. Switchboard; Fig. 3. Part of Boiler Room; Fig. 4. Power House; Fig. 5. Turbine Room; Fig. 6. Basement beneath Boilers, Showing Means for Removing Ashes; Fig. 7. Pumps and Condensers

reinforced-concrete floor, which is closed by a flat gate sliding horizontally. A railroad track runs under each row of boilers and the ashes are discharged into steel hopper-bottom cars kept standing in the basement. This arrangement eliminates all ash-handling machinery and the loaded cars can be hauled out and dumped on parts of the wharf site where the fill has not yet been completed.

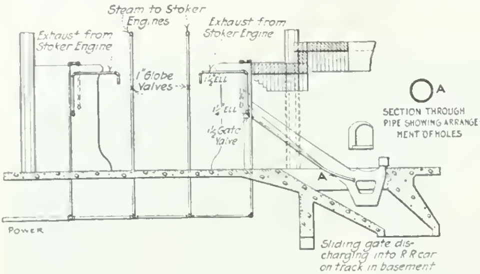

Steam to Stoker Engines
Exhaust from Stoker Engine
Exhaust from Stoker Engine
1" Globe Valves
1½" Ell
1½" Ell
1½ Gate Valve
A
A
SECTION THROUGH PIPE SHOWING ARRANGEMENT OF HOLES
Sliding gate discharging into R R car on track in basement
POWER

Fig. 8. Section through Furnace

The boiler room contains three 600-hp. boilers with superheaters, each having an independent steel stack 66 in. in diameter and 125 ft. high. Two of the boilers are on the side adjoining the turbine room while the third is on the west side of the boiler room. The floor space is sufficient to install three additional boilers as soon as the demands warrant such extension.

PRINCIPAL EQUIPMENT OF WEST BREAKWATER POWER PLANT, CLEVELAND, OHIO

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Stirling water-tube	600 hp.	Main units	150 lb. pressure, 100° superheat	Babcock & Wilcox Co.
3	Stokers	Roney inclined grate	110 sq.ft.		Ohio screenings	Westinghouse Mach. Co.
2	Engines	Vertical, single-acting	4¼x4 in.	Stoker drive	150 lb. pressure	Westinghouse Mach. Co.
2	Pumps	Centrifugal 2-stage	350 gal. per min.	Boiler feed	438 ft. head, 3100 r.p.m.	De Laval Steam Turbine Co.
2	Turbines	Reaction	40 hp.	Drive boiler feed pump	150 lb. pressure, non-condensing	De Laval Steam Turbine Co.
1	Coal hoist	Monorail trolley	2.5 tons, 300 ft. per min.	Receiving trough to bunkers	Grab bucket, 66 ft. hoist	Sprague Elec. Co.
1	Coal crusher	2 roll				
1	Feed water heater	Open	2500 hp.	Boiler feed heater	Exhaust from auxiliaries	Harrison Safety Boiler Works.
1	Air compressor	Single stage	12¼x12 in.	Railroad switches and house service	100 lb. pressure	Ingersoll-Rand Co.
1	Motor	Induction	75 hp.	Air compressor drive	3 phase, 60 cycles, 220 volts	Westinghouse E. & M. Co.
3	Generators	Alternating current	750 kv.a.	Main units	3 phase, 60 cycles, 2300 volts, 3600 r.p.m., 98% regulation	Allis-Chalmers Co.
3	Turbines	Horizontal reaction	750 kw.	Main unit	150 lb. pressure, 100° superheat, 3600 r.p.m.	Allis-Chalmers Co.
3	Condensers	Jet		On main units	28-in. vacuum	Allis-Chalmers Co.
3	Turbines	Horizontal reaction	50 hp.	Drives circulating water and air pump	150 lb. pressure, non-condensing	Kerr Turbine Co.
1	Generator	Direct current.	25 kw.	Exciter	208 amp., 120 volts, 2400 r.p.m.	Allis-Chalmers Co.
1	Turbine	Horizontal reaction	25 kw.	Drive exciter.	150 lb. pressure, non-condensing	Allis-Chalmers Co.
1	Generator	Direct current	25 kw.	Exciter	208 amp., 120 volts, 850 r.p.m.	Allis-Chalmers Co.
1	Motor	Induction	34 hp.	Exciter drive	3 phase, 60 cycles, 2200 volts	Allis-Chalmers Co.
3	Rotary converters	6 phase, 60 cycle	600 kw.	A.C.-D.C. transformation	175 volts A.C. to 250 volts D. C., 2000 amp.	Westinghouse E. & M. Co.
3	Transformers	Oil insulated water cooled	550 kv.a.	Rotary converters	3 phase, 60 cycles, 2200 volts to 6 phase, 175 v.	Westinghouse E. & M. Co.
1	Equalizer	Flywheel motor-generator	500 kw., 25,000 hp.-sec.	Peak load on direct current circuits	250 volts, 2000 amp., floats on line 600 to 720 r.p.m.	Westinghouse E. & M. Co.
1	Switchboard	Alternating and direct current	21 panels	Power control		Ft. Wayne Wks., General E. Co.
2	Rectifier sets		50 lamp	Arc lamps D. C magnetite		General Electric Co.
2	Pumps	Duplex reciprocating	3½x2¼x3 in.	Main unit lubrication	150 lb. pressure, non-condensing	T. M. Prescott Co.
3	Transformers	Oil insulated	5 kw.	Lighting	Delta-delta connections, 2200 volts, 110 volts	Pittsburgh Transformer Co.
3	Transformers	Oil insulated	40 kw.	Power	Delta-delta connection, 2200 volts to 220 volts	Pittsburgh Transformer Co.
1	Strainer	Elliot twin	5 in.	Water service		Elliot Co.
2	Pumps	Vertical twin volute	5 in., 500 gal. per min.	Water service	30 ft. head, 1133 r.p.m.	Watson-Stillman Co.
2	Motors	Induction vertical shaft	15 hp.	Drive service pumps	3 phase, 60 cycle, 1133 r.p.m.	Westinghouse E. & M. Co.
1	Crane	Hand traveler	15 ton.	Turbine room.		Whiting Foundry Equipment Co.
	Water meters			On boiler feed lines.		Henry R. Worthington
	Piping and valves	All				Pittsburgh Valve, Foundry & Equipment Co.

There is a 2500-hp. feed-water heater in the boiler room and the exhaust steam from the feed and circulating-water pumps is led to this heater, which is supplied with water from the house-service system. From the heater, the feed water flows down to the basement to a pair of twin volute turbine-driven boiler-feed pumps controlled by pump governors. The water-supply to each boiler is controlled by feed-water regulators. The boiler-feed lines are in duplicate and normally operate together, but either may be shut down without interfering with the operation of the plant. There are meters in the feed lines.

Of the two steam headers, the main header is furnished with superheated steam but so connected that the superheaters can be short-circuited if desired; an auxiliary header is supplied direct from the drum of the boiler.

In the generating equipment, there are three 750-kv-a. turbogenerators driven by Parsons-type turbines at 3600 r.p.m. and provided with jet condensers. The generators deliver three-phase, 60-cycle current at 2200 volts and excitation is provided by a motor-driven and a turbine-driven exciter, each of 25-kw. capacity.

As previously stated, the unloaders and the ore bridge are operated by 250-volt direct-current motors. The motor equipment of the ore bridge comprises the following:

		Hp.
2	225-hp. hoisting and loading motors	450
2	75-hp. trolley traveling motors	150
2	75-hp. bridge traversing motors.	150
2	25-hp. operating gates on loading hoppers.	50
	Total	800

The nominal capacity of this bridge is 1000 tons per hr.; the hoisting speed of the 15-ton bucket, 175 ft. per min.; the trolley-travel speed, from 600 to 800 ft. per min., and the bridge travel 50 to 75 ft.

The four ore unloaders, having a capacity of from 35,000 to 40,000 tons per day when operated double turn, are equipped with 17-ton buckets and have the following motors on each machine:

		Hp.
1	300-hp. walking-beam hoist motor.	300
1	100-hp. trolley motor	100
1	100-hp. bucket-closing and opening motor	100
1	25-hp. bucket-rotating motor	25
1	150-hp. receiving hopper operating motor.	150
1	150-hp. larry car hauling motor	150
1	35-hp. larry car gate operating motor.	35
	Total	860

In addition, direct current is supplied to a battery of narrow-gage electric poling locomotives, used to spot cars under the unloaders when they discharge cargo direct into the cars.

The direct-current peak load from the four unloaders will approximate 2000 kw. and that from the ore bridge is about 1600 kw. The fluctuations are rapid, swings of from 1200 to 1500 kw. frequently occurring at intervals of from 15 to 30 seconds. Three 600-kw. rotary transformers supply this direct-current load and to smooth out the violent swings a 500-kw. flywheel motor-generator set is kept floating on the line. This machine has three bearings and the armature shaft carries, in addition, a 20-ton flywheel built up of heavy steel plates. Windage losses are reduced by inclosing the wheel in a steel-plate housing. Under normal conditions, the speed of this machine ranges from 600 to 720 r.p.m., acting as a motor, absorbing power at the higher speeds and restoring power to the line as the speed drops. A liquid field regulator automatically regulates the speed so that the load on the rotary transformers is held within 10 per cent. variation. The storage power of the flywheel is approximately 25,000 hp.-sec. and the machine is designed to carry a 100 per cent. overload 10 sec. out of every 2 minutes.

Design of Ashpits

By T. A. Marsh

SYNOPSIS—Features to be observed in building ashpits. How to figure their capacity. Faults and merits of typical designs.

* * *

There are several fundamental principles to consider in connection with any designs or recommendations made for ashpits. As discussed in this article the considerations apply strictly to chain grates, but the general principles hold for practically every kind of stoking apparatus. The features to be observed are:

1. The pits should be of ample capacity.
2. The removal of ash from the pits should be accomplished by a minimum amount of labor.
3. The design should be such that the maintenance cost of valves and doors is minimum.

These features also hold true regardless of the type of carrier or conveyor which disposes of the ashes after they are removed from the pits, although the type of carrier is one of the items which must govern the kind of pit adopted.

Capacity of Ashpit

It is desirable to design ashpits of a sufficient capacity to accommodate the ashes from an 18- or 20-hr. run. Such pits avoid the necessity of a night shift for ash handling and insure the stoker equipment against those ills consequent to permitting ash and clinker to accumulate up to the stoker mechanism.

While it is seldom possible to obtain pits of such ample capacity, with the modern ideas and proportions of designs, pits having capacities of 12 to 11 hr. are usually obtainable. The latter, while not quite safe from an operating standpoint, do away with the night ash-handling shift, providing the ash-disposing system is ample to perform this work in the day time and if the day shift leaves the ashpits clean when it goes off duty.

The problem of providing sufficient capacity is simple. Determine the maximum amount of fuel that can be burned on the grate. This is a product of the pounds of coal burnable per square foot of grate surface per hour and the number of square feet of grate surface. The contractor's specifications usually state both of these items. In the absence of such specifications or guarantees a study of the draft provision will give a basis on which to estimate the combustion rate, as the handbooks and catalogs of the boiler and stoker companies have information regarding the combustion rates obtainable with any given draft.

It is desirable to use the maximum rate on the assumption that some day it will be necessary to operate for a considerable period at that rate regardless of the station's supposed requirements and the designer's intentions. The maximum percentage of ash or refuse should be then considered and ample allowance made for the lowest grade of fuel in the market. The product of the percentage of refuse and the hourly fuel consumption will be the number of pounds of ash and refuse obtained per hour.

A study of average test results with the fuels under consideration will serve as a guide to the percentage of ash and refuse to use in the foregoing calculations. With the high-grade fuels of the Atlantic seaboard it would be safe to provide for refuse to the amount of 10 per cent. of the fuel, with coals of the Pittsburgh district 15 per cent. and of Illinois and Indiana 20 per cent. Coals of Iowa and some Southwestern localities contain as high as 40 per cent. of ash by analysis.

A cubic foot of ash weighs from 40 to 50 lb., depending upon its quality. For safety in allowing ample proportions, 10 lb. should be used. In this way the capacity in cubic feet necessary to accommodate one hour's ash is determined, and an analysis of any proposed design can at once be made from a standpoint of suitable capacity; or a pit can be proportioned to hold the ash and refuse for a given period of operation.

Ease of Cleaning

It is important that the ashes be removed from the pits without unusually hard and disagreeable labor, otherwise the pits will not be cleaned regularly and properly. It will be difficult to retain laborers for this work and the cost of removal will be high, to say nothing of damage to the ashpits and stokers if the pits are habitually permitted to become overfilled.

From this second standpoint the design of pits is largely one of motion study and of the method used in removing ash. From these considerations it is desirable to have the discharge door at a convenient height for the operator to use a hoe or a shovel, whichever the particular design may call for. It is better to have this door too low rather than too high.

Pits must also be so designed that there is ample room to use a hoe or shovel. Some pits necessitate hand shoveling, and when this design is used, there should be plenty of room to use a shovel. In other designs the ashes are hoed forward, but the distance they are to be drawn must not be too long (8 ft. is about the maximum): there must be clearance for the hoe as the ashes are dragged forward.

Where valves are used on ash hoppers, see that the valves can be opened and closed readily from the floor and while the ash car is under the valve. Moreover, such designs should provide means for inspecting the hoppers to see that the ashes have been thoroughly discharged and for readily poking down any lodged ash or clinker without danger to the operator.

Pits that are relatively small but are accessible and easily cleaned give better results than large pits involving heavy labor and perhaps some danger.

MAINTENANCE

The maintenance cost of ashpits is often high, particularly where there is considerable clinker and where the sulphur content is high. It is desirable from an operating standpoint, and usually from the maintenance point, to provide ashpits with a water-sprinkler system to quench the ashes. However, if there is exposed steelwork the corrosion will be rapid and the maintenance cost will go up.

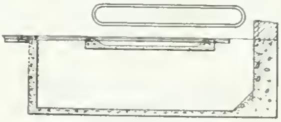


FIG. 1

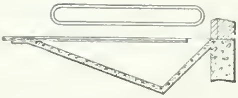


FIG. 2

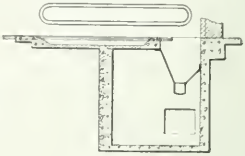


FIG. 3

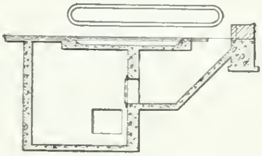


FIG. 4

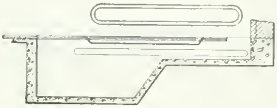


FIG. 5

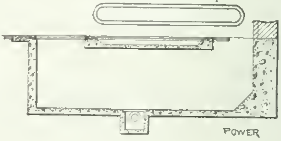


FIG. 6

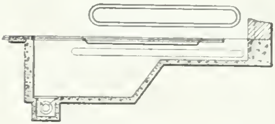


FIG. 7

Showing Several Designs of Ashpits

Concrete- or brick-lined pits are most desirable and those pits which do not permit ash and clinkers to pile against the discharge doors or valves give the best all-around results. The reasons for this are that when ashes are piled against the discharge doors, no matter how well these doors are made, there will be a considerable air leakage, and this air drawing through the ash will continue the combustion of any unconsumed fuel. This action results in a mass of clinkers in the ashpit or hopper which is difficult and perhaps dangerous to remove. Moreover, the combustion against the discharge doors results in the rapid warping and burning of the metal parts. Many types of stoker should have tight ashpits which it is practically impossible to maintain after a few weeks' operations with pits of a design permitting ash to accumulate against the discharge doors.

Bearing directly upon the cost of maintenance of ashpits is their accessibility. Some are provided with long chutes or small valves or doors which are inaccessible and the cost of repairing the pits or relining them is consequently higher than normally.

TYPICAL DESIGNS

To make the discussion specific, a number of ashpit designs are shown and attention is called to their faults or merits. They by no means cover the field but they are somewhat typical and serve to represent certain principles.

Small plants of 1000 hp. and less seldom have any but manual means for handling ashes, and ashpits of the designs shown in Figs. 1 and 2 are usually employed.

Fig. 1 represents a plain pit of rectangular section and has in its favor cheap construction. The length of this type necessitates that the ashes be hoed forward and then be shoveled out into a barrow or car. Such pits should be used only in plants operating four or less boilers, as any excess will warrant a more elaborate system of ash removal. An analysis of this design indicates that it can seldom be made of ample capacity; the removal of ash is difficult but the maintenance is extremely low.

Fig. 2 represents a sloping pit. Such pits are used where it is impossible to excavate to a proper depth, but the results are usually unsatisfactory. The design is a failure from the capacity standpoint and also largely from the point of ash removal.

Fig. 3 indicates an ash hopper. These can be made of various designs and are frequently used in the largest stations. It is preferable to have such hoppers lined with firebrick. They should have large valves, preferably 24 or 30 in. square, as this is a type in which the ash clinkers against the discharge valve. Some designs have been made with diverging sides so that the ash and clinker cannot lodge. This pit indicates that it can be made of ample capacity and that if care be taken in the design the removal of ash is not difficult, but its upkeep is against it; in addition, it is difficult to inspect and to repair.

The pit shown in Fig. 4 is a desirable design and can be made to meet the proper requirements better than any of the others discussed. Ample capacity is provided and the ashes are retained on a horizontal brick-lined or concrete floor and are not in contact with the metal discharge door. There is no tendency, therefore, for the door to warp and become leaky, and the ash itself remains in the same finely divided state in which it was discharged from the grate.

Ashes are removed by a hoe from this pit, and the designer should make sure that the horizontal distance of the ashpit floor is not over 8 ft. He should also see that there is fully 8 ft. clearance in front of the door for the handle of the hoe when withdrawn. These pits when 6 ft. wide or under should have one 24-in. square cast-iron door; when in excess of this width two doors of this size should be provided.

This design has the three features of capacity, ease of ash removal and low maintenance. It can be modified to permit shoveling from the floor in cases where the head room is slight or modified to permit hoeing into a railway car where basements are designed along such lines.

Sometimes due to soil conditions, to pipe lines or to other local conditions, it is undesirable to excavate for an ashpit in front of the bridge-wall and the pit has to be put forward in front of the boilers. This necessitates the use of an ash drag or conveyor, as shown by Fig. 5. The mechanism for such a device is simple and the results obtained are satisfactory. The arrangement costs more than the plain pit, Fig. 1, but requires less labor for ash removal, although this is partially offset by the additional labor consequent to an additional piece of conveying machinery. The capacity of such a pit is low, but the danger of overfilling it is removed, the ashes being drawn forward where they can do no harm.

Special types of ash-conveying machinery improve some of the designs materially, for instance, the plain pit shown in Fig. 1. When provided with a steam-jet system or a pneumatic ash-handling system, Fig. 6, it becomes a desirable design as to ease of ash removal, although the capacity of the pit is still limited.

The hopper arrangement, Fig. 3, lends itself to almost any type of conveying machinery or car system, as does that shown in Fig. 4.

The design shown in Fig. 5 can be improved by using the pneumatic ash-handling system or a steam-jet conveyor, Fig. 7.

The foregoing considerations cover only the general principles involved and specific cases require special design. However, their application may serve as a guide in laying out this feature of the power plant.

⁂

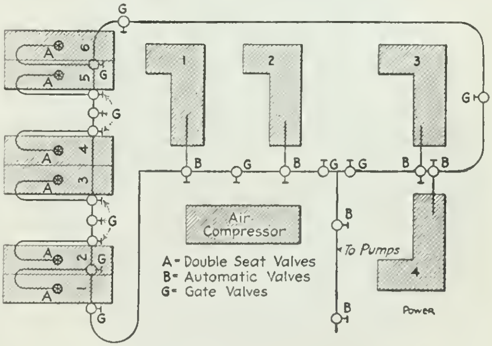
What the Engineer Can Do Among the functions of the operating engineer none is more important than advising the plant owner in the purchase of new equipment. The more able an engineer is in selecting the best apparatus, the greater his value to his employer and the more likely that the right types of machines go into the plant. Today the plant owner expects more of his engineer than doing routine operating work, and often studying machinery contracts, specifications and correspondence in connection with former purchases has well repaid the engineer

Nonreturn Valves on Engine Steam Pipes

By J. C. Hawkins

Nearly all states and cities with boiler-inspection laws require that where two or more boilers are connected to a common header and the pressure is over 10 lb., there shall be two valves on the branch to each boiler, one of which shall be nonreturn. This is to lessen the danger of employees being scalded by escaping steam when a tube blows out, when any other accident happens to prevent a shutdown of the rest of the plant, and to make it impossible to turn steam into a cold boiler whether it is standing idle or undergoing repairs.

Although these rules apply to the boilers only, they should be applied to the main steam line. Frequently a steam pipe bursts or an engine is wrecked, causing loss of life and severe damage that would have been much less with the proper installation of automatic valves. As boilers are often set, there are only a few feet between their tops and the ceiling. The same may be said of the main steam line. If a tube blows out, a valve or fitting on the steam line breaks or the engine is wrecked, it is usually impossible to get to the valves on the main line to close them until the steam is off the entire plant; even if the valves can be reached, they usually have a long thread and turn hard, requiring considerable time for closing. For this reason the nonreturn valve, as usually installed, protects the boiler to some extent, but no other part of the plant; neither does it protect the boiler from having all of the steam and a greater part of the water drawn through a break in the steam line. Protection of the boiler is all that the law requires, but it is only a part of what is really desired.



Boiler-Piping Diagram, Showing Valves

Take, for instance, a plant with the steam line arranged on the loop system as shown in the sketch. There are several boilers, engines and pumps. The boiler laws require that a nonreturn valve be placed on the boiler branch near the boiler as at A. With two or more on the line, a tube blowout or other accident will cause valve A on the disabled boiler to close, thereby preventing the steam from escaping from the other boilers or header. If, however, a fitting or valve in any part of the steam line breaks or an engine is wrecked, this valve is useless, and the steam in all the boilers may escape. This valve should be of the compound or double-seat type, and so balanced that a sudden draft of steam in either direction will cause it to close.

In case of accident to the main line, this would cause every boiler to be cut out automatically and only the steam in the header would escape. The sudden rise of pressure in the boilers due to closing the steam outlet while there was a heavy fire would be taken care of by the safety valves.

These automatic valves contain several parts which must work freely if the valve is to function, and usually it has levers or springs on the outside. As any of these parts may get out of order, the valve should be placed at the boiler with a gate valve between it and the header so that whenever it needs attention, it is only necessary to cut the boiler out. These valves should always be provided with means of indicating whether the valve is open or closed. They must be so placed that no water pocket will be formed. In cutting a boiler into service the gate valve at the header end should be opened first by equalizing the pressure through its bypass; then the stem of the automatic valve should be turned up. This will permit the boiler to be automatically cut into service when the pressure reaches the desired amount.

Automatic engine stops are often used to quickly close the throttle if the engine overspeeds, but many times accidents are caused by water in the cylinders.

To prevent the escape of steam an automatic valve should be placed at the engine branch as shown at *B*. The location of the valves, which usually are of the outside screw-and-yoke type, is such that they could not be reached in case of accident until the steam is all blown off. The system of piping also contains a large volume of steam, which in escaping may do the goods considerable damage, as in a department store. With an automatic valve at this point, a sudden draft of steam would cause that particular line to be cut out without interfering with the operation of the rest of the plant. This valve would necessarily have to close in the direction which the steam is flowing, and be nicely adjusted to remain operative and yet not close with a sudden increase in load on the engine.

Some of these valves are so arranged that they may be operated by a solenoid or by steam or air pressure and be closed from any part of the plant. If so arranged, they would act as an engine stop, as well as an automatic valve.

*

Maxim Safety-Valve Silencer

A recent development on the principle of the Maxim silencer is a device for eliminating the noise of blowing safety valves and of the boiler blowoff when fitted to the outlets of either.

The steam is led into passageways of increasing area, fitted with sound traps to prevent the passage of sound waves along with the steam. By making these passageways of sufficient area the velocity of the steam is brought down to a point where the noise of its escape to the air is not objectionable.

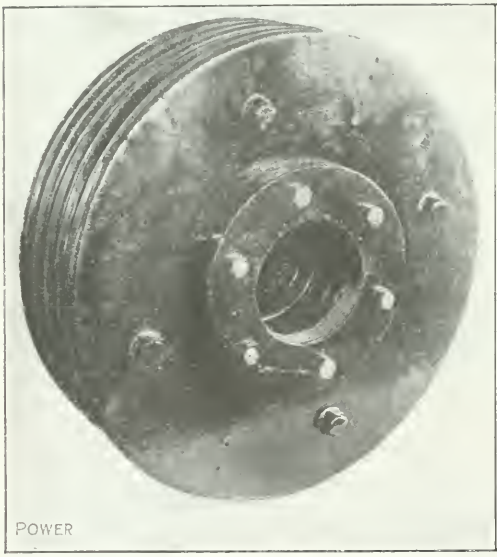


Fig. 1. Maxim Silencer for Steam Safety Valve

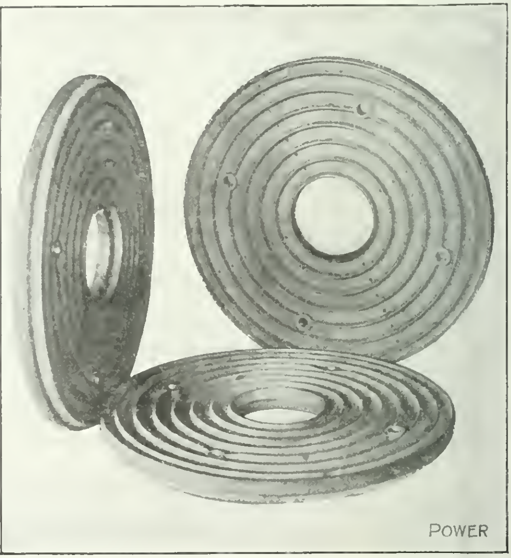


Fig. 2. Details of Design of Silencing Chamber

In the safety-valve silencer, Fig. 1, the final outlet area is nearly 20 times the area of the safety valve, and the velocity of the steam is not only proportionately lower by virtue of this area, but also on account of the cooling and the reduction of the volume.

An interesting feature of the silencer is the noise trap, Fig. 2, which provides an endless channel in which the sound waves circulate until they disappear. The traps are so arranged that the escape of the sound waves from trap to trap multiplies the frequency of the wave. This is continued until the frequency is carried above audibility and is also smoothed over so as to secure approximate uniformity of one sound wave with another.

The silencer for the boiler blowoff is constructed on similar lines to that used for the safety valve, but it has a receptacle for the collection of solid matter, which avoids abrasion and wear of the internal surfaces. The Maxim Silencer Co., Hartford, Conn., are the manufacturers.

Locating Faults in Direct-Current Armatures--III

By F. A. Annett

SYNOPSIS—Testing for short-circuits, open circuits and cross-connected coils by means of a millivoltmeter and a low voltage current.

* * *

There are several ways of testing for defects in armatures, one of the most common being by the use of a millivoltmeter or an ammeter without a shunt, as in Fig. 1. An instrument having a permanent magnetic movement is preferable, as this type is usually more sensitive than others, and will read only with the current flowing through in a certain direction; otherwise, the needle will deflect back off the scale. It is especially desirable in locating cross-connected coils, as will be seen later. In making the test, first pass through the armature a direct current of such strength as will give ample deflection on the instrument, preferably about half way across the scale. This current may be supplied from any low-voltage source, the amount passing through the armature under test being regulated by a rheostat, or a bank of lamps, as shown. The testing instrument should be connected to three or four pairs of adjacent segments to get an average reading, and then proceed systematically around the commutator, testing from bar to bar.

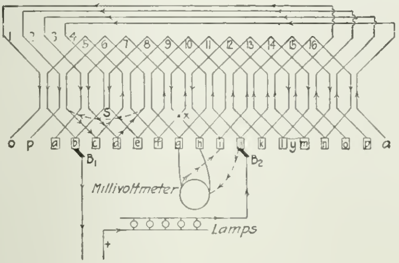


FIG. 1

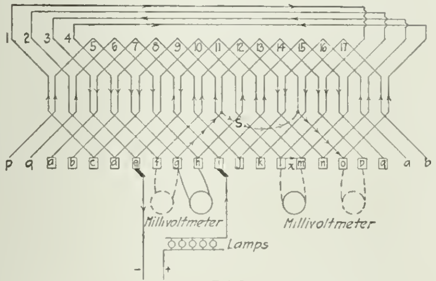


FIG. 2

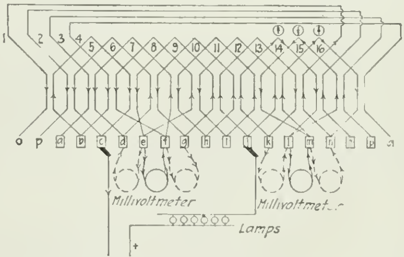


FIG. 4

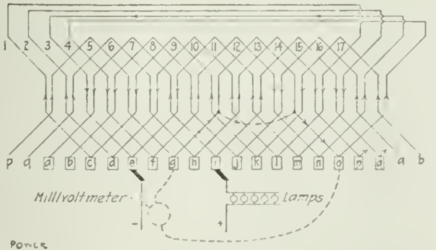


FIG. 3

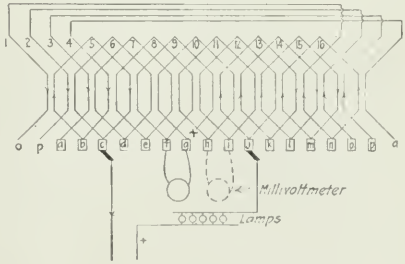


FIG. 5

Armature Windings, Showing How to Locate Short-Circuits and Cross-Connected Coils

The effect obtained from a short-circuited coil or a short-circuit between commutator segments will be understood by reference to Fig. 1. In tracing out the current from brush B_2 around through the armature winding to brush B_1, it will be seen that the short-circuit at x, between coils 8 and 11, shunts coils 9 and 10; therefore no current will flow through them. Also, coil 6 is represented short-circuited at s. This will cut out all or part of coil 6, and the voltage drop across it will be less than across the good coils.

If the instrument is connected to segments i and j, it will give normal deflection, providing everything has been adjusted properly; likewise, when connected to segments h and i. When connected to segments g and h or f and g, however, it will not show any deflection, as no current is flowing through coils 9 and 10; hence there is no voltage drop across them. This shows that coils 9 and 10 are short-circuited.

If there is not good contact at x, some current will flow in coils 9 and 10, depending upon the resistance at x, which the instrument will indicate by a reduced deflection. After passing segments f, g and h, the instrument will give normal reading until connected to segments c and d, where it will again give a reduced deflection, indicating that coil 6 is short-circuited. This would again occur between segments *l* and *m*, where the short-circuit is not in the coil but between the segments as represented by *y*. When a short-circuit is thus indicated, in order to find out whether it is in the coil or the commutator, it will be necessary to disconnect the coil leads from the segments between which the fault was located and test across them with a lamp. In this case it would not light between *c* and *d*, indicating that the defect is in the coil, which may be removed and repaired, or repaired as explained in connection with Fig. 2, part 2 (Nov. 17 issue). On the other hand, if a test is made across segments *l* and *m* with the coil leads disconnected, the lamp will light, which would indicate a short-circuit between the commutator bars. This is usually caused either by solder getting on the back end of the commutator or the mica carbonizing between the segments.

After a commutator has been trued up in a lathe, it should be carefully inspected before testing, to see that the tool has not drawn the copper from one segment to the next across the mica, thus causing a short-circuit. An easy way to make this inspection is to moisten a piece of cloth or waste with oil and hold it on the commutator while turning in the lathe. This turns the segments a deep copper color and the mica black; consequently, if at any point the copper has been drawn from one segment to another, it will be readily detected.

In an armature that is series (wave) wound, as in Fig. 2, a little more consideration is necessary to locate the defective coil. Coil 13 is shown short-circuited by the dotted line *s*; also a short-circuit is shown between segments *l* and *m* at *x*. It will be seen by tracing out the circuit that the short-circuit between segments *l* and *m* cuts out coils 2 and 10, or a coil for each pair of poles. This is true for any number of poles; in a six-pole machine, a short between commutator bars will short-circuit a group of three coils located 120 deg. apart in the winding; for an eight-pole winding, four coils 90 deg. apart, etc.

If the testing instrument is connected to segments *g* and *h*, it will read the drop across coils 14 and 5, which should give a normal deflection. Again, connecting it to *f* and *g* will give the drop across coils 13 and 4. Coil 13 is short-circuited at *s*; therefore the drop across it will be less than across a good coil, and the deflection on the instrument will be less than normal, indicating a short-circuited coil. When the instrument is connected to segments *o* and *p*, it will again read the same as at *f* and *g*, indicating the other terminal of the defective coil.

The exact location of the faulty coil may now be determined by connecting one terminal of the instrument to a segment between which the defective coil was indicated, such as at *g*, Fig. 3, and testing to the segments in the other location of the fault, such as *o* and *p*. When connected to *o* it will be across the terminals of the faulty coil. This will be indicated by a very low reading or no reading at all. A reading taken across *l* and *m*, Fig. 2, will be very low, and will indicate a short-circuit between the segments at that point.

The indications that will be obtained on a millivoltmeter or ammeter for a cross-connected coil will be understood by referring to Fig. 4. The instrument is shown connected in three positions at segments *d, e, f* and *g*, with the coil leads to segments *e* and *f* interchanged. When the testing instrument is connected to *d* and *e*, it will give a deflection double that of normal. By tracing out the circuit from *e* to *d*, it will be seen that the current passes through two coils in series, which will cause a double voltage drop between these segments. If the testing instrument is connected to segments *e* and *f*, the current will flow through it in the opposite direction, as indicated by the arrowheads, and the needle will deflect backward off the scale. In taking a reading across segments *f* and *g*, a deflection will be obtained the same as at *d* and *e*. If the leads to *e* and *f* are now interchanged, and another reading is taken across these segments, a normal deflection will be obtained.

The leads to coil 15 are shown crossed at segments *l* and *m*. If readings are taken at positions *kl, lm* and *mn*, the instrument will give a normal reading in each case, reading the same across the cross-connected coil as the others; therefore a coil connected this way cannot be located by this method. A practical way of locating a coil connected in this manner is to explore with a compass the polarity of the magnetism from coil to coil at the back end of the armature. A cross-connected coil will give a reversed deflection, as shown at coil 15. The compass should be held slightly above the level of the coil.

Open-circuited coils may be located in the same way as explained for short-circuited coils, only the defective coil will be indicated by a full scale deflection on the instrument, as will be understood by referring to Fig. 5. Coil 9 is shown open-circuited at *x*, and if the winding is connected as shown, current will flow from segment *j* through the part of the winding indicated by the arrow-heads, but cannot flow through the coils left blank, for the circuit is open at *x*. Taking readings between *k* and *l*, *l* and *m*, etc., a normal deflection would be indicated, but if the instrument is connected to *i* and *h*, it will not read, for there is no current flowing through coil 11; therefore there is no voltage drop across its terminals; likewise across coil 10. However, when the instrument is connected to segments *f* and *g*, it bridges the break in coil 9 and there will be an abnormal deflection of the needle. If the coil leads are not properly soldered to the commutator segments, a comparatively high resistance exists in the connection. This will be indicated on the instrument by a deflection higher than normal.

This method of testing can also be used to locate a grounded coil in the armature winding; but, instead of testing from bar to bar, one terminal of the instrument is connected to the shaft and with the other terminal a bar-to-bar test is made on the commutator, the location of the grounded coil being indicated by a very low reading on the instrument. After the two segments that give the lowest reading have been located, disconnect the coil terminals from them and test for the ground with a lamp. If the winding is parallel-connected, the two segments to which the grounded coil is connected will be located together; if series-connected, they will be located two pole spaces apart.

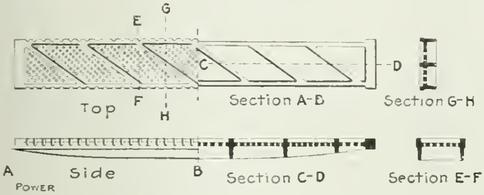
To distinguish between a parallel- and a series-connected armature winding, first note the center of the coils at the back end of the armature. If the leads to the commutator are in the same direction as the back ends of the coil—that is, swung in toward the center—the winding is parallel-connected. If the leads swing around the armature away from the center of the coil, the winding is series-connected. This will be readily understood by comparing Figs. 1 and 2.

The location of the testing-current connections to the commutator must not be overlooked. If the armature is parallel-connected, the connections should be 180 deg. apart, whereas in series-connected armatures the connection should be one pole space apart, namely, 90 deg. on a four-pole machine, 60 deg. on a six-pole machine, etc.

⁂

Directions for Burning Lignite

That there is estimated to be more than thirty billion tons of lignite in Texas, this deposit covering an area of more than 60,000 square miles, is directing more and more attention to its use in boilers. This fuel is already extensively used in manufacturing plants. Dr. William B. Philips, of Austin, director of the Bureau of Economic Geology and Technology of the University of Texas, has recently investigated the sources of lignite and its commercial use and gives his conclusions in a recent report.



Grate for Burning Lignite

Eight years ago it was the custom for the miners to load nothing but mine-run lignite, but since the introduction of a grate adapted to burn lignite screenings, this grade is sold at from fifty to sixty cents a ton, f.o.b. mines.

This grate, shown herewith, is like the ordinary grate, being approximately rectangular in cross-section and wider at the top than at the bottom. On its top face are marginal and transverse ribs or partitions, forming fuel pockets adapted to retain fine fuel. On its bottom face are recesses forming air pockets. These fuel pockets are from one-half to five-eighths of an inch deep and are connected with the air pockets by tapered ventilating holes, largest at their lower ends, being about three-eighths of an inch in diameter at the top and 50 per cent. larger at the bottom. The tapering form of the ventilating holes tends to cause a discharge of the air in jets into the fuel.

In ordinary grates, especially where a forced or induced draft is used, the air rushes through the weakest places in the fire. With this grate the individual air pockets underneath prevent the air from rushing past some of the ventilating holes and overcharging others. These air pockets form sources of supply to the separate groups of ventilating holes and cause an even distribution of the air to the fuel pockets in the top of the bar throughout the grate surface. A steam blower is used with these grates.

Much lignite is now fired by hand, and while this method unquestionably gives good results when proper care is taken, the stoker seems to be necessary for large establishments. There are no difficult obstacles to be overcome. The main points to consider are that lignite is a fuel which parts with its volatile combustible matter more quickly than does ordinary bituminous coal and that the fixed carbon is not of a coking nature. This means that a large quantity of air must be supplied within a short time after the fuel begins to part with its volatile combustible matter and is supplied at the requisite points. The smoke must be prevented from forming, for it is difficult to handle it afterwards. The fixed carbon will take care of itself, if prevented from falling through the interstices of the grate; it is the volatile combustible matter that has to be cared for.

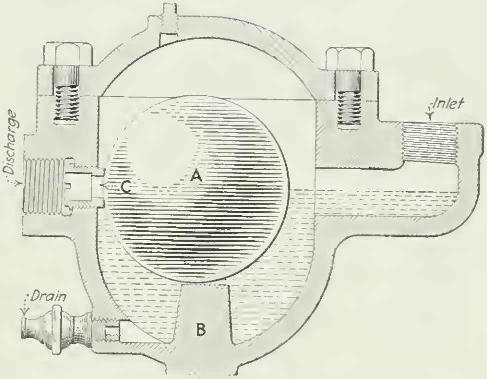
It does not appear that there are greater variations in the composition of lignites than in the coals with which they are to compete, so that a stoker installation successful with one lignite should be capable of burning any other under comparable conditions.

⁂

Brown Steam Trap

It would be difficult to design a steam trap more simple than the Brown, which consists of a body, a discharge orifice and a float. The sectional view of the trap shows the interior construction. The float *A* is tested to 300 lb. pressure and rests on the projection *B*. When the trap has discharged the float seats against the discharge orifice *C*.

When condensate enters the trap through the inlet the ball floats, opening the discharge orifice and permitting a constant discharge of water without loss of steam. There is also a constant discharge of air and the trap does not become air bound.



Section through Brown Steam Trap

This trap, which is manufactured by the D. G C. Valve Co., Fuller Bldg., New York City, has no working parts and but one moving part, the rolling ball, which seats in a new place each time and cannot get out of order. The trap will handle water against any back pressure less than the pressure at the trap. It is made in $\frac{3}{4}$-, 1- and $1\frac{1}{4}$-in. size, with 700, 1000 and 1700 lb. of water per hour capacity respectively.

⁂

Labeling of Incandescent Lamps—Why are incandescent lamps usually labeled with three voltages, such as 110, 112 and 114 volts?

H. E.

To indicate the voltages for which they are adapted. For obtaining full efficiency and candlepower they should be burned at the highest voltage indicated. At the next lower voltage they will burn with a somewhat decreased efficiency but will have a longer life. At the lowest voltage the efficiency will be still less and the candlepower will be about 80 per cent. normal, but the life of the lamp will be almost double that at the highest voltage.

The Franklin Flue-Gas Analyzer

To overcome the troubles experienced with Orsat apparatus having pinch or glass cocks, Frank Duemler, Olney P. O., Philadelphia, the inventor and maker of the Franklin analyzer, uses a unique kind of valve for the tube connections to the pipettes.

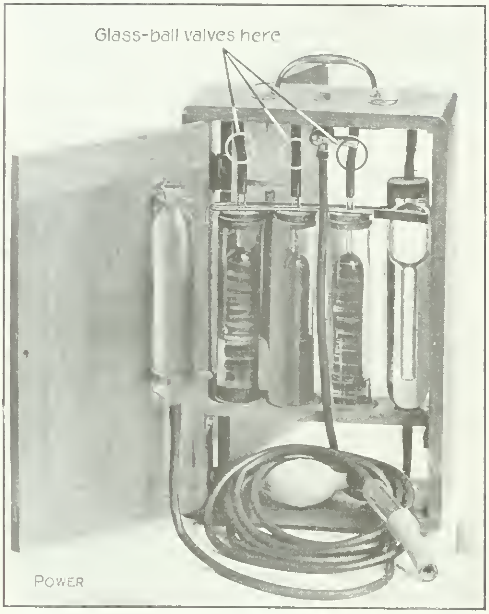


Fig. 1. The Franklin Analyzer

As pinch cocks tend to "chew" holes in the rubber tubes and glass cocks frequently stick fast, Mr. Duemler uses an oblong glass ball or pellet inside the rubber tubing from each pipette, the pellet being a tight fit in the tube. When it is desired to run the gas into a pipette, simply squeeze the tube surrounding the pellet with the thumb and forefinger as shown. This stretches the rubber away from the pellet, affording the gas a passage. This is shown in the enlarged sketch, Fig. 2.

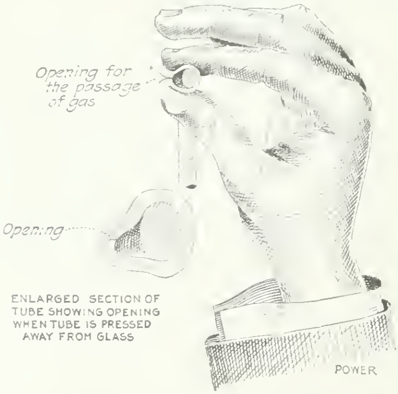

Opening for the passage of gas
Opening
ENLARGED SECTION OF TUBE SHOWING OPENING WHEN TUBE IS PRESSED AWAY FROM GLASS
POWER

Fig. 2. How the Tube Is Pressed Away from the Glass Pellet to Allow the Gas to Pass

Other commendable features of the apparatus are its accessibility and the ease with which the pipette may be dismounted and reloaded. The hinged spring wire, shown in Fig. 1, rests hard on top of the pipettes and is latched in notches on the side of the frame.

The apparatus may be used for O_2, CO and CO_2 determinations. Its price is $25.

⁂

Care of Low-Tension Ignition System

By A. L. Brennan, Jr.

Low-tension ignition, commonly referred to as mechanical make-and-break ignition, formerly was used almost exclusively, but has now given way, especially in small high-speed engines, to the high-tension, jump-spark system. This has been due chiefly to the greater flexibility of the latter. However, low-tension ignition offers a few advantages over high-tension sparking devices, principally because it is not so easily affected by moisture; therefore, motors thus fitted are better suited to operate under exposed conditions.

Since the movable electrode projects through the side of the cylinder, a certain amount of wear will result in a loss of compression; also, the actuating mechanism is subject to wear, which may interfere slightly with correct timing.

The spark produced by a mechanical igniter takes place while the points are being separated and not while they are apart, therefore it is important to have the actuating and controlling parts in good condition. The tension of the springs should be kept up to insure the points making a rapid break, and springs which have become weakened through wear or high temperatures can be improved by drawing them out a little, although it is better to substitute new springs wherever possible.

The contact points of the movable and stationary electrodes should be kept bright and free from carbon or other foreign deposits. Points that have become pitted will require filing, but in doing this care should be taken to work the contacts down to such an angle that their entire surfaces will touch. Unless this is done, no matter how clean the points may be, it will not be possible to obtain the best spark. If there is a decided tendency toward pitting, the current should be reversed about once a week.

Low-tension systems are subject to many of the troubles of other types, short and open circuits playing important rôles in this respect. The chief difference between an open and a short-circuit is that in the former the circuit is not complete, such as when the switch is open, while in the latter the switch is closed, but the current passes through a path of less resistance and fails to complete the circuit. Therefore, when confronted with ignition trouble, it is well to look to the switch first, as it is quite possible that it has been left open. If the switch is all right, the trouble can be traced to one or more of the following:

1. Loose or broken wires;
2. Broken-down insulation on wires;
3. Loose battery connections;
4. Dirty igniters;

5. Igniters "hung up" or otherwise inoperative;
6. Weak batteries.

If a storage battery is used, test with a low-candlepower lamp. Dry cells may be tested with an ammeter and should show at least 10 amp. If, on testing the set, there is no flow of current indicated, it is well to test each cell separately, for it often happens that a cell will be dead or affected by an "interior short," and thus affect the set.

To test a low-tension system, close the switch (if it is of the "exposed-blade" variety), and then pull it out quickly. If a spark appears at the contacts, the circuit is all right, and the trouble may be looked for in the igniter. On the other hand, if no spark appears at the switch, it would not necessarily show that the circuit is at fault, for unless the igniter points are together the circuit is open. Therefore, close the switch again, and with any handy tool complete the circuit from the stationary electrode to the motor and note if a good spark occurs.

Kv.-A. and Kw. Ratings and Effects of Low Power Factors

By A. L. Temple

Today, most alternating-current apparatus is rated and bought on a "kv.-a." basis of rating. Operators who have been used to dealing with direct-current apparatus or have a "kw." basis for loading their generators and transformers often fail to consider the importance and value of the kv.-a. rating in heating and other overload troubles at times of peak loads. Again, it is often thought that the kv.-a. rating is one thing and the kw. rating another, which is not strictly true, for every kv.-a. rating has several corresponding kw. ratings. This relation can be understood when it is remembered that the kv.-a. rating of a piece of alternating-current apparatus is independent of the power factor and equals volts times amperes, as shown by the switchboard meters. The kw. rating, on the other hand, does depend upon the power factor—that is, it varies with the power factor for the load that the machine can carry continuously without damage from heating. For such a load the kw. capacity is reduced as the power factor decreases and increases as the power factor is raised until, when the power factor is 100 per cent., the kw. and kv.-a. ratings are equal.

The kv.-a. rating is a help in indicating the safe load that a machine can carry because such a load depends upon the heating effect or the amperage flowing through the windings. If the power factor is low and the operator believes the machine to be capable of carrying 220 kw., with a generated voltage of 2200, then when the ammeter shows 100, he is led to believe that while the recording wattmeter shows that 220 kw. is not exceeded, he can run up the load, say to 125 amp. If the nameplate reads 220 kv.-a. instead of 220 kw., then in this case the machine was fully loaded at 100 amp., and the reason the wattmeter did not show this was due to the power factor being low. If it took an indication of 125 amp. to show 220-kw. load, then the power factor was 80 per cent., a value often found on circuits carrying induction motors. If, as in this case, the machine had a kv.-a. rating of 220, its kw. rating at 80 per cent. power factor was 176 kw. and at 90 per cent., 198 kw.; that is, the machine would heat the same when carrying 176 kw. at 80 per cent. power factor as when carrying 198 kw. at 90 per cent. power factor. Thus by dividing the kv.-a. rating by the circuit voltage the safe current that can be carried by the winding is found, and the kw. load that can be carried to not exceed this current when induction motors are operated can be found as follows:

kw. ÷ power factor = kv.-a. = amperes × volts

Allowable amperes = kw. ÷ (volts × power factor)

where the kw. is taken from the recording wattmeter, and the power factor is obtained by dividing the kw. wattmeter reading by the kv.-a. nameplate rating.

From this it is seen that if apparatus is ordered by a kw. rating it is necessary to state the power factor under which it will operate, so as to secure a machine large enough to carry the load expected.

A low power factor is very objectionable. When making extensions or additions to a system, a larger size of wire, and a larger transformer must be used than required with a higher power factor and a voltage drop is produced that is out of proportion to the drop due to the working current of the actual load. This makes it hard to hold a steady voltage, for any great variation of operation and load on the devices causing the low power factor cause fluctuations that are hard to control at the station except through continual juggling of the exciter fields or by means of expensive automatic devices.

When a low power factor is found on any system, the first thing to do is to find out the cause, which can generally be located in induction motors too large for the load carried and running light most of the time, transformers much too large for the load, and in a large number of arc lamps used on a power circuit. When such causes are found it is wise to change the motors and transformers if possible and place the arcs, if burned while the motor load is operated, on a separate circuit. If this cannot be done easily, it will be found worth while to consider the installation of a synchronous motor at some point on the line preferably near the center of load or in a substation or at the end of the line, if only one line is operated. The synchronous motor has a neutralizing effect and brings the conditions back to normal. This is brought about in the following way:

With a low power factor there flows in the lines a wattless current, which lags behind the voltage. By overexciting the fields of the synchronous motor it delivers back to the line a current leading the voltage. When this adjustment is made so that the current leads the voltage as much as the wattless current lags, then the power factor would theoretically be 100 per cent. It is found in practice that the size of motor required to bring about this ideal condition is more costly than the benefit of the improved power factor after reaching about 90 per cent. Up to this point a relatively small capacity of synchronous motor has a decided corrective effect. The use of the synchronous motor is attractive because at the same time it can carry 70 per cent. rated load as a motor.

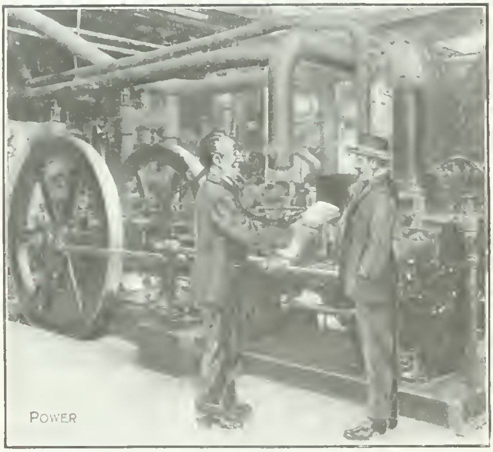
New York City Engineers' License Law

By Bill B. Banger

Well, fellers, it's so long since I've had a confab with th' bunch about this, that and t'other that I don't know whether I'll get into print or not. It's up to th' boss editor whether I can multiply a few pros and cons now and anon, but that's as may be.

Th' question before th' house is, "Has th' rights of th' American engineer been preserved?" and th' answer comes echoin' down the coal chute, "Damfino, but it's doubtful if they has."

Now, it all depends on where you live and whether you want a job as an engineer. If you are a workin' engineer in New York City you'll probably believe th' rights of th' American engineer are all to th' good, seein's you'll probably take th' stand that all engineers livin' on th' outside are aliens with no more rights than a skunk in a sittin' room.



"I Told Williams I Wasn't Workin' with a New York City License, Didn't Have to and Hadn't Any Idea of Gettin' One, Police Department or No Department"

If you are livin' outside of New York City and happen to be so situated that a job at engineerin' has just got to be had to keep th' kids from goin' to th' poorhouse, you'll think you are worse nor a half-breed idiot, so far as rights go.

Th' engineers' license law of New York City is to my belief unconstitutional, and there's a lot of engineers in th' city gifted with a fair amount of human intelligence who think th' same. Gettin' down to anchor bolts, th' law must have been framed by a set of muts who, havin' a job, were mightily afraid they couldn't hold on if other engineers—who knew just as much, and probably more—were given half a chance to get into th' game and show some of 'em that all th' efficient engineers were not workin' in New York City.

This fact was brought vividly to my mind, as Tennyson—maybe 'twas Captain Marryat—says, by a long-time friend of mine who can set up an engin' with his eyes shut, and knows more in a minute than some engineers I've met in the city knows in a month. The firm he was workin' for was foolish enough to lose most of their money, and so it was a case of get a job operatin' until times were better. Seein's New York's his jumpin'-off place, and has some companies what knows a good engineer when he shows up—and want a good man anyway, whether he shows up or not—Williams, we'll call him, because it ain't his name, got a job as soon as he got onto Broadway.

Then he meandered down to police headquarters to make application for a license to run th' plant. As proof he wasn't playin' a flim-flam game, what is worked so easy in the Metropolis, Williams takes a Philadelphia city license and an Ohio State plaster, both of the first-class ratin', along as evidence to his standin' as an engineer.

But there was nothin' doin'. It didn't make a durned mite of difference how many gold-sealed plasters were put on exhibition, Williams found that he had to get th' signatures of three city engineers what had a license and were workin' at their trade and could certify that th' statements contained in th' application were true.

Some chance fur gettin' a license, by heck, fur a feller what don't know three engineers in th' whole burg. But it's evident to even a soused bum that a feller couldn't get two first-class licenses if he hadn't put in a few licks at throttle-twistin'.

This condition of engineerin' affairs is what a lot of engineers in th' city favor, so as to keep outsiders from playin' in their ash heap.

When Williams blew into my engin' room and wanted me to sign his application for a license, I told him I'd do it so quick he'd think th' last world's series was bein' played if it would do any good, but th' fact was, I wasn't workin' under no New York City license, didn't have to, and hadn't any idea of gettin' one, police department or no department.

That kind of knocked Williams into a heap, so I went on to explain that th' license law was so loosely constructed that it was only necessary to have one licensed engineer on watch, no matter how many engineers were workin.'

"But you are th' chief engineer of this plant, ain't yer?" says he.

"You can put down your last dollar that I am," says I, "and there's no law to stop me from hangin' up my hat in this engine room and bein' th' cock of the roost, and if you have a licensed engineer in th' plant you want to run, all you've got to do is to get the company to tack on th' title of buildin' manager, assistant superintendent or somethin' else as meaningless, so as to get past a law what aims to keep you out of a job.

"Strictly speakin,' accordin' to law I ain't th' chief engineer here, but, on th' other hand, what I say goes first shot off th' bat, and it don't make any difference to me whether I'm called a chief or somethin' else."

In lookin' over Williams' application I noticed one question put on with a rubber stamp, "Have you ever been convicted of a felony?" Williams said he hadn't, but it struck me as bein' mighty nigh onto a joke for the police inspection department to ask such a question. Some fellers don't seem to have a mite of humor.

As have other menial engineers, I have wondered now and anon, so to speak, just why th' inspection of boilers and th' issuin' of engineer certificates in New York City should be performed by th' police department. It don't stand to reason that a cop is capable of protectin' th' public against boiler explosions.

Under th' date of March 22, 1913, Charles G. Armstrong & Son submitted a report on th' system of boiler inspection and licensing of engineers and firemen under th' police department of New York City for th' aldermanic committee, in which was cited examples of th' trainin' of some of th' boiler squad previous to their service as "engineers." One feller actin' as a boiler inspector was previously a letter carrier, clerk and gasfitter, another had been a fireman and an oiler, and a third had held down the job of patrolman. One examiner, th' feller what looks you in th' face and passes judgment on your fitness to operate a steam plant, had been a clerk, lumber inspector and timekeeper. Now, how in tophet does these qualifications fit these men to do their full duty in an intelligent manner with justice to all and malice toward none?

Sometimes I think—but what's th' use? Th' law is on th' books and will be enforced if you don't get th' title of manager or somethin' else to sidestep this piece of unjust legislation what no engineer can be proud of and what takes away an American's rights to earn an honest dollar at his trade.

Them's my sentiments and if you don't like 'em it ain't my fault. Somethin's wrong somewhere, by heck!

⁂

Large Wheeler Cooling Towers

The accompanying illustration shows what is believed to be the largest cooling tower project ever undertaken. This battery of forced-draft towers was built for the Texas Power Co., Waco, Texas. They are of the steel shell type, arranged in a battery 100 ft. long, 18 ft. wide and 40 ft. high.

There are six pairs of 10-ft. fans operating at 250 r.p.m., and are belt driven by motors above each pair of fans in small motor houses. The fan housings are extended and are provided with doors which may be opened to permit of the unobstructed entrance of air by natural draft during the winter season. A platform, reached by a ladder from the ground, serves the three motor houses; an upper gallery is built on the level of the water distributors and the water-regulating valves which control the water discharge to each compartment.

Any section may be cut off for inspection or cleaning without interfering with the operation of any of the others. The water piping is designed for an additional installation of towers of equal capacity to the left of the present battery. The present equipment is designed to cool 600,000 gal. of water per hour. These cooling towers were built by the Wheeler Condenser & Engineering Co., Carteret, N. J.

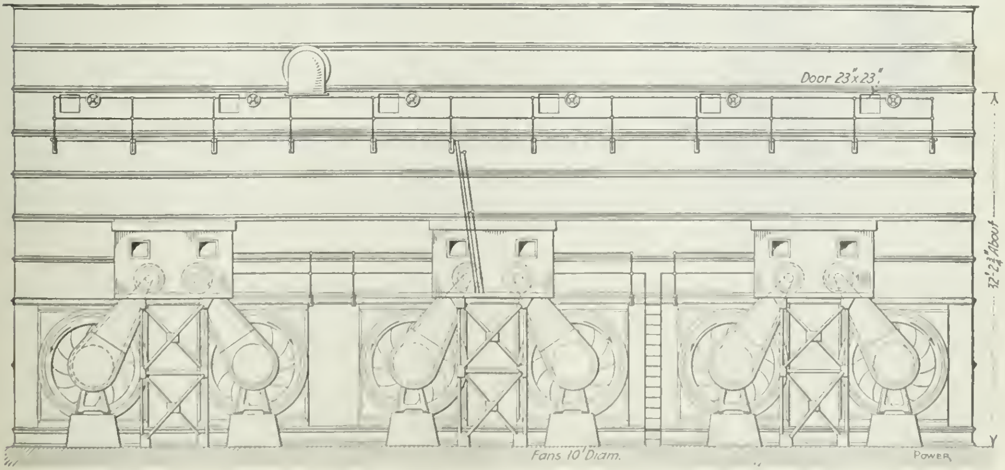
⁂

Calculating Pump Slippage

By J. C. Hawkins

One way to determine the approximate slippage* is to place a gage on the discharge side of the pump between the discharge chamber and the main discharge valve; also have a 1-in. pipe tapped into the discharge line at this point, with a valve and a short length of pipe attached. Then place barrels on scales or have a tank of known capacity to weigh or measure the test water. Close the main discharge valve tight or blank off the pipe if necessary and start the pump, letting it run only fast enough to keep the pressure up to that at which it is working when in service. Then open the test valve to the weighing barrels or tank, regulating the speed of the pump to maintain the same pressure in the discharge chamber.

When the test valve is opened count the number of



General Arrangement of Cooling Tower

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*Pump slippage is the difference between the water which should go out (displacement) and that which does (delivery), and is due to leaky pistons, plungers or valves.

strokes of the piston until the tank is full. Calculate the displacement of the piston per stroke, multiply by the number of strokes and reduce the product to pounds or gallons, as desired. This will give the quantity of water that should have been pumped. Then weigh or measure the water actually pumped and divide by the displacement of the pump, which gives the percentage of water actually delivered at the average working pressure. This percentage subtracted from 100 gives the percentage of slippage that should be deducted as calculated from the displacement.

The slippage found in this manner may not be correct for the reason that part of the valve slippage takes place while the valve is closing and would be greater at high than at low speed, because the valve opens wider and the piston reverses quicker, but it is correct for all usual purposes.

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R F M Flow Meter

A new type of flow meter for steam, air, water and gas has recently been made by the Republic Flow Meter Co., of Chicago, formerly known as the Steam Appliance Co. The measurement is made electrically and the result in units of flow may be read on the dials of electrical instruments which, in reality, are special ammeters.

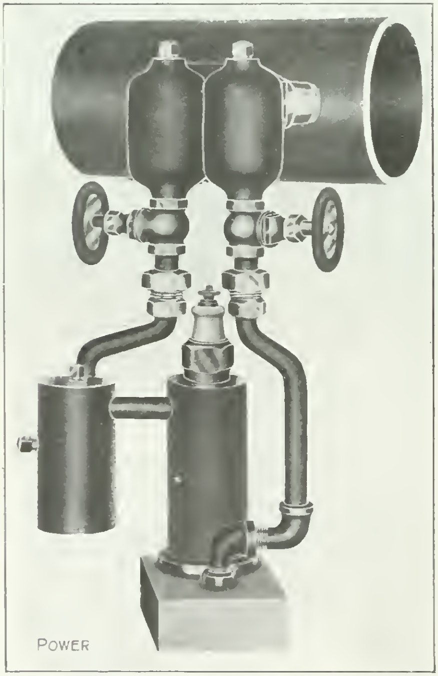


Fig. 1. R F M Meter Attached to Steam Pipe

The difference between the dynamic and static heads, or the velocity head in the pipe containing the medium to be measured, affects the height of a mercury column which in turn changes the resistance in the electrical circuit. As the velocity of the medium increases in the pipe to which the meter is attached, the mercury rises, cuts out resistance and consequently increases the current, so that the reading on the dial is greater.

An external view is shown in Fig. 1. It consists of two interconnected cylinders, two reservoirs, or condensers, and two meter tubes, the last named being shown to advantage in Fig. 2. The principle of operation, however, is more apparent in Fig. 3, as the cylinders are shown in section. The larger cylinder has a mercury well at the bottom and at the top a resistance spool of "Advance" wire. From a fiber plug, on which the spool rests, steel wires, arranged in the form of a cylinder and of graduated lengths, project downward. These vertical wires are attached to the wire on the spool at different points of its length, so that a circuit may be formed through the entire resistance or through portions of it. The terminal plug is screwed into the top of the cylinder. The larger cylinder is sealed by the mercury well, and above that is filled with oil, as is the upper part of the smaller cylinder. The bottom part of the latter contains water.

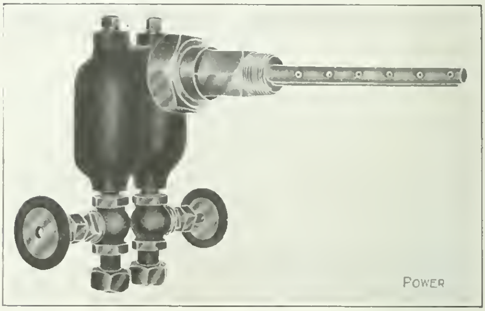


Fig. 2. Meter Tubes and Reservoirs

When the medium is steam, the meter tubes, Fig. 2, enter the steam pipe through a single plug and can be turned in any position and the tube used for either vertical or horizontal pipes. The tube in the foreground connects with the dynamic reservoir and the openings shown must always face toward the direction of flow. The other tube connects with the static reservoir and the holes face to the rear or away from the flow of steam. The reservoirs are merely condensers which fill the connecting pipes with water. The dynamic head, due to pressure and velocity, bears down on the mercury well and tends to force its contents up into the cylinder. The static head—the pressure—is transmitted from the smaller cylinder to the larger, and resists the upper movement of the mercury. The difference in pressure, or the velocity head, determines the height of the column of mercury, and this height fixes the resistance left in the electrical circuit.

A set of instruments is furnished consisting of an indicating meter *A*, Fig. 3, a recording meter *R* and an integrating meter *I*. All three may be mounted on one board or individually at the points desired. It is also possible to duplicate the instruments; that is, have one meter or a complete set in the boiler room and another in the office, all giving readings from the one flow meter. The indicating meter is a special make of ammeter designed for one ampere. The recording meter is the same thing with a recording arm attached and clockwork to revolve a twenty-four-hour chart. The integrating meter is specially designed so that the counters will move about ten times as fast as in the usual type of wattmeter.

These meters operate on alternating current only, at a pressure of 38 volts. A small transformer reduces the voltage of the supply to this point. In case there is only direct current in the plant, a rotary converter is added to the equipment at small expense.

The flow meter is not as complicated as the description would indicate; it is compact and hangs in one piece from the plug. The use of different types of instruments with the one flow meter and their location at any point desired form an arrangement unusually convenient. As the meter is sealed there is no opportunity for the mercury to oxidize. Moderate prices and accurate measurement of the flow, due to the accuracy of the electrical instruments, are among the claims.

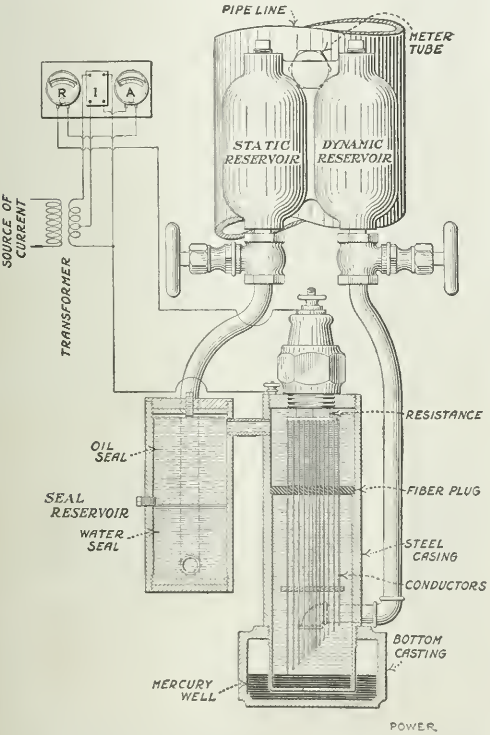


Fig. 3. Section through Meter and Electrical Connections

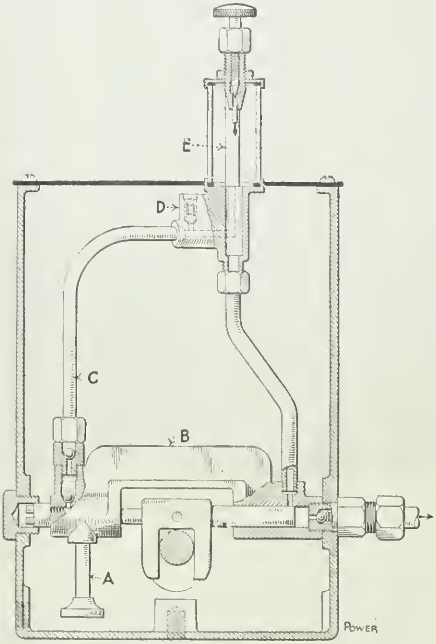
* * *

What Copper Casting Alloys Contain—Composition and approximate melting point of some of the more common casting alloys containing copper, zinc, tin and lead:

	Composition				Melting Point,
Alloys	Copper	Zinc	Tin	Lead	Deg. F.
Gun metal	88.0	2.0	10.0	.	1825
Leaded gun metal	85.1	1.9	9.7	3.0	1795
Red brass.	85.0	5.0	5.0	. . .	1780
Low-grade red brass	81.5	10.4	3.1	5.0	1795
Leaded bronze.	80.0	. .	. .	10.0	1735
Bronze with zinc. . .	84.6	5.0	10.4	.	1795
Half yellow, half red	75.0	20.0	2.0	2.0	1690
Cast yellow brass. . .	66.9	30.8	. . . .	2.3	1615
Naval brass.	61.7	36.9	1.4	. . . .	1570

Krahn Force-Feed Lubricator

This oil pump is designed with a complete pump unit for each feed and can be removed without disturbing any other unit. The mechanism, fastened to the pump body, is immersed in oil, and, as the drive is positive, there is no slip between the driving medium and the ratchet, the driving lever of which moves through an angle of 76 degrees.



Sectional View of the Krahn Force-Feed Lubricator

An auxiliary hand lever is furnished with the ratchet pump and a disengaging head with the direct-drive pump so that oil can be forced to the engine bearings before starting.

The pump lever is operated from any suitable source on the engine and on the ratchet-driven pump a ratchet revolves the pump shaft in one direction, giving movement to the pump plunger through a crosshead. On the direct drive the pump shaft oscillates to give the plunger the required stroke.

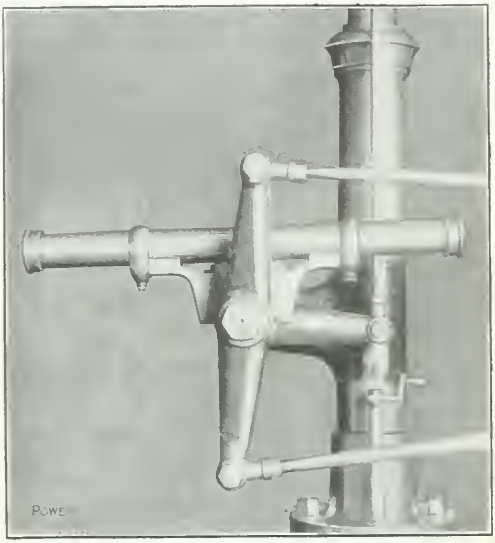
Oil is drawn by the plunger through the inlet pipe *A* into the cylinder *B*. On the return stroke the oil is forced into the pipe *C*, past the bypass *D* into the regulating valve *E*, where it drops from the drip nozzle through the sight feed and outlet pipe into the cylinder *B* and is forced out into the feed line past the check valve by the pump plunger on the next stroke.

This pump is made for 3-, 4-, 6- and 8-quart capacities with from one to eleven feeds. Compartment pumps are also built so that two grades of oil may be used.

This pump is made by the Krahn Manufacturing Co., Clinton and Lapham Sts., Milwaukee, Wis.

Corliss Governor Compensator

An ingenious device designed to assist the flyball governor of a Corliss engine in maintaining the speed within 1 per cent. from no load to 25 per cent. overload is shown in the accompanying illustration. It was patented in December, 1909, by C. P. Hall, chief engineer of the Rookery Building, Chicago, but has not received mention in the technical press.



Compensator on Corliss Governor

The compensator consists of a tube 1½ in. in diameter, 19 in. long, capped at both ends and divided into several compartments which are partially filled with mercury. It is placed on top of the hub of the rocker-arm to which the reach rods are attached and secured by means of a saddle and stirrup. A space of 2½ in. is necessary between the governor rod and the inner face of the rocker-arm. The compensator is mounted level on the rocker-arm hub when the engine is running light at its usual speed and is bolted rigidly in place. Then when the governor tilts the rocker-arm in either direction, the compensator follows, and the mercury, concentrating its weight in the same direction, automatically aids the governor. In other words, the compensator has the same effect as automatically increasing or decreasing the weight of the balls when the engine speed is either side of normal. It thus adds to the power of the governor, and as the perforated division walls between compartments do not allow a sudden shift of the mercury, the compensator tends to steady the action of the governor and prevents racing.

For the past five years one of these compensators has been in operation on a 20x42-in. Corliss driving directly a 200-kw. direct-current generator at 100 r.p.m. The engine had seen 18 years of service before the device was applied. The load consists of lights and motors in an office building and varies from 100 to 250 kw., although not in a single shift. By actual count over a considerable period the speed did not vary one revolution. In rolling mills, sawmills and other places where the variation in load is extreme, the compensator should prove of value.

Dry-Jacket Soot Blower

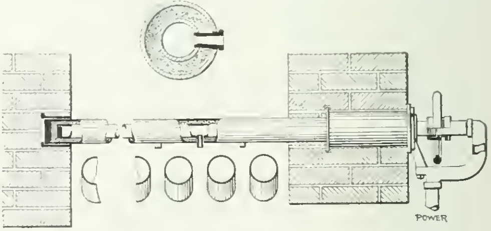
The dry-jacket soot blower is designed for use with a water-tube boiler and is intended to withstand high furnace temperatures without having to be replaced at short intervals.

The blower units which are exposed to a deteriorating temperature are made of two wrought-iron tubes, one within the other. The outside tube is 3½ in. in diameter, with a ½-in. space between the inner and outer tubes, which is filled with a specially prepared heat-resisting compound. These units are baked in ovens at an extremely high temperature until the compound becomes hardened and tile-like in formation.

This material is pressed tightly around the inner tube and forms an insulator so that the tube does not become red hot even in the hottest furnaces.

Another feature about this device is that each unit revolves on its own bearings and directs the steam between the tubes where soot may lodge. In cases where a complete revolution of the blower is not necessary, stops are provided to eliminate the waste of steam. The illustration shows a unit in its correct position with respect to the tubes.

Each unit is equipped with steel expansion nozzles which force the steam around and between the tubes at a high velocity, estimated to be 2500 ft. per second, although no more steam is used than with an ordinary opening of the same size. Units not within reach from the floor are operated by sheave wheels and chains.



Blower in Correct Position with Respect to the Tubes

This blower is manufactured by the Diamond Power Specialty Co., Detroit, Mich.

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Electrolysis Regulation in St. Paul—Following a brief report by Ray Palmer, commissioner of gas and electricity, Chicago, and recommendations on electrolysis on water mains in St. Paul, the water board will present bills to the street railway company for damages due to stray currents and ask the latter to coöperate with the board in the establishment of return feeders and continuity of service. In case the company refuses, Mr. Palmer recommended the passage of regulating ordinances similar to those in force in Ohio, St. Louis and Chicago.

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Saved by a Bolt—In connection with the wreck of the gantry crane at the Marion station of the Public Service Corporation of New Jersey, we learn that a similar accident nearly occurred at the Bayonne works of the Babcock & Wilcox Co. Their large bridge crane ran to the end of the track and sheared off ten sets of track bolts, all that prevented it from going over being a last bolt which was half sheared off, but held.

Valve Area in Pumps

By A. B. Morrison, Jr.

SYNOPSIS—Discusses the relations of valve area to valve lift and pump speed.

In the selection of a reciprocating pump, whether direct-acting or power-driven, or in analyzing the operation of a pump which may not be giving satisfaction, the valve area is one of the most important things to investigate.

Valve area is usually expressed in percentage of the piston area, the actual net area through the valves being taken. The space occupied by the ribs and valve-stem support is subtracted from the area given by taking the circle whose diameter is the inside diameter of the valve seat. This net area is considerably less than would be given by taking the area of the rubber valve itself. For example, a 3-in. valve has a net area of less than 4 in., taking the valve as a whole, whereas the area of a 3-in. disk, such as the rubber valve, is from 40 to 50 per cent. of the area corresponding to the valve size.

Valve area in itself is not a sufficient criterion by which to judge a pump without knowing the size of the pump cylinder, the type of pump and the duty. The percentage of valve area in a given pump should be known in order to know the mean velocity of the liquid through the valves. This may be as high as 250 ft. per min. through the suction valves on large pumps, providing the pump is carefully designed for the service, and is usually the same through the discharge valves, which for shop reasons are generally made the same both in size and number as the suction valves. Broadly speaking, 200 ft. per minute is considered standard, the same as 100 ft. per min. piston speed is considered standard, both being approximate rules.

It is apparent that a small pump can have a smaller percentage of valve area to piston area than a large one and still operate satisfactorily. For mechanical reasons it is not practicable to run a short-stroke pump fast enough to approximate a piston speed of 100 ft. per min. A pump with 3-in. stroke, for instance, to run at 100 ft. piston speed, would have to make 100 strokes per min. Even though the pump could run at this excessive speed and not shake itself to pieces, the valves obviously could not open and close fast enough to keep up with the strokes of the pump. On the other hand, a 36-in. stroke pump running at only $33\frac{1}{3}$ strokes per min. would give 100 ft. piston speed. Such a pump could operate at 40 strokes, or 120 ft., per min. without trouble and probably would be rated at this speed. Similarly, a 24-in. stroke pump at 50 strokes would give 100 ft. and would probably be rated at 25 revolutions.

Suppose that the 3-in. stroke pump is rated to give its capacity at 60 revolutions or 120 strokes. Then the piston speed is

$$\frac{120 \times 3}{12} = 30 \textit{ ft. per min.}$$

If the net valve area is 30 per cent. of the piston area then the velocity through the valves would be

$$\frac{30}{0.30} = 100 \textit{ ft. per min.}$$

If the 24-in. pump is operated at 25 revolutions or 100 ft. piston speed, with 30 per cent. valve area, then the velocity through the valves would be

$$\frac{100}{0.30} = 333 \textit{ ft.}$$

which is too high. Such a pump would have at least 50 per cent. valve area, giving 200 ft. velocity through the valves at the rated speed of 25 revolutions. It is apparent, therefore, that the factor to be considered is not the percentage of valve area alone, but the velocity through the valves as well, the latter being directly proportional to the former and dependent on the speed; the percentage of valve area usually depends on the size of the pump.

The size and shape of the water end have much to do with the satisfactory operation of the pump. If the water passages are large and direct, the pump will be more satisfactory at high speeds than if the water passages are narrow and long.

The size of the valve, regardless of its area, is also important. Suppose in a given pump the valves are nominally 6 in. diameter. The net area through the valves determines the velocity through the seat, but in order to secure egress, the liquid, after passing through the seat, must raise the valve and escape around the circumference. The valve area is a function of the square of the valve diameter, whereas the circumference of the valve is directly proportional to the diameter. The 6-in. valve would have an approximate net area of 14 sq.in., this being taken as 50 per cent. of the area of a 6-in. circle, 28.27 sq.in. Assume that the diameter of the inside of the valve seat over which the water must pass is approximately 5.5 in., the circumference of which is 17.3 in. That the liquid may pass out over the circumference of the

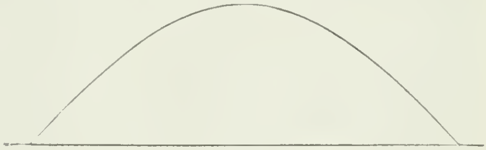


FIG. 1.

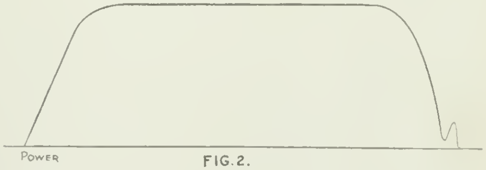


FIG. 2.

Discharge Velocity Curves from Power-Driven and Direct-Acting Reciprocating Pumps valve at the same velocity as it passes through the seat, the valve must be lifted

$$\frac{14}{17.3} = 0.809 \textit{ in.}$$

If the pump were short stroke and running at high speed there might not be time enough for the valve to raise and seat quietly and hammering might result. Suppose that 4-in. valves were substituted for 6-in. Assuming the area through the 4-in. valve to be 6.3 sq.in., or one-half of the area of a 4-in. circle, and the inside diameter of the valve seat to be 3⅝ in., which gives a circumference of 11.38 in., the lift of each valve would be

$$\frac{6.3}{11.38} = 0.554 \textit{ in.}$$

or slightly more than half an inch. This condition would be more likely to insure quiet running, assuming the valve area to be the same in both cases.

If a pump is operating under heavy discharge pressure the speed must be low and the valve area large, with a slow water velocity to make sure of filling the cylinder and giving the valves time to seat before the pump starts its return stroke. On a high suction lift large valve area is a necessity, and here, too, slow speed is required. Before the valves can open, a considerable vacuum must be created and time allowed for the water to fill the cylinder before the return stroke is made. A pump on a high suction lift is likely to be troubled with air leaking through the joints of the suction pipe or entrained in the suction and released when the vacuum necessary to pull the water is produced. If the strokes are rapid, this air may not be expelled, but will be alternately compressed and expanded, causing the pump to knock and race. The same effect would be had if the valve area were so small that the pump could not fill properly, though in this latter case the trouble would be due to a partial vacuum and not to the air. With hot liquids, owing to their tendency to vaporize, slow speed is also essential.

The question as to relative valve areas between a direct-acting steam pump and a power-driven pump is hard to answer. Fig. 1 shows the velocity curve of the piston of a power-driven pump and Fig. 2 the curve for a direct-acting duplex pump, the hump at the end being caused by the cushioning. If the valve opening and closing followed in point of time the curve of the piston velocity, then the power pump would have the advantage, for the opening and closing would be gradual. This assumption does not appear to be borne out in practice. More power is required to open the valves than to hold them open, and a considerable vacuum is sometimes necessary in the cylinder before the valve raises. The opening and closing of the valve do not follow the velocity curve but are behind it. With the duplex direct-acting pump the motion is more rapid, as will be noted from the curve, and probably the valves open more quickly than in a power-driven pump and remain open for a longer time. The cushioning at the end allows the valves to seat before the return stroke is commenced. It would appear that for a given length of stroke the direct-acting pump would operate better on a lower percentage of valve area than the power pump, this conclusion being reached for the reason that probably the valves are open full for a greater part of the stroke. However, a power pump is nearly always a constant-speed machine, whereas the steam pump can be run at almost any speed within its limits, and is likely to be speeded at times beyond its rated and regular capacity. It is safe to figure on the same percentage of valve area for either type for the same sizes.

In pumping heavy and viscous liquids, as oils, tars, etc., the valve area should be larger than for water, since these liquids flow more slowly and the cylinder will not fill as readily. If the liquid has a specific gravity somewhat greater than water it should be remembered that for a given suction lift the vacuum produced by the pump must be greater than for water. A column of the liquid would exert a greater pressure than a similar column of water, due to its greater specific gravity, hence the vacuum in the cylinder must be greater for the pressure of the atmosphere to raise the liquid a given height.

The following table gives the average speed at which pumps of a given stroke are usually run (a revolution being taken as two strokes of a direct-acting pump) together with the percentage of net valve area advisable for both suction and discharge considered separately. These speeds may vary considerably up and down due to local conditions, particularly on the smaller sizes, a high suction lift, heavy viscous and hot liquids and high discharge pressures decreasing the speed; suction under pressure and low discharge pressure increase it.

Length of Stroke in Inches	Average maximum Revolutions per Minute	Minimum per Cent. Valve Area Advisable
2	80	20
3	70	20
4	60	25
6	60	35
8	55	40
10	55	50
12	50	50
16	40	50
18	30	50
20	30	50
24	25	50
36	20	60

On the shorter-stroke pumps the valve area is usually larger and the water passages are likely to be restricted.

⁂

Flow of Steam Through Pipes—There is perhaps no phase of power-plant design in which the rule-of-thumb methods are still adhered to so commonly as in the determination of the proper size of steam pipes.

This is due, apparently, to several reasons; the commonly accepted formulas are complex, are not any too well substantiated by experimental data nor based on sound theory; the tables given by various writers are incomplete and inconvenient. The engineer who installs pipes which are too large will seldom be criticized, for the mistake shows but slightly in the first cost of the entire plant and the large radiation losses remain unnoticed. Many designers overestimate the importance of keeping the pressure drop in the lines low. Loss of pressure in a pipe line carrying any fluid is due to friction, and results in the transformation of energy of motion of the fluid as a whole into molecular energy or heat. In a water line this heat is usually a total loss, but with steam flowing in well covered pipes most of this heat is carried on with the steam, raising its temperature or its quality. Thus, instead of being able to figure the percentage loss of power as being equal to the percentage of pressure, as is usually true for water or electricity, the loss is materially reduced by the return of the heat to the steam. Or, the total energy of each pound of steam just after entering the pipe is, heat energy + pressure × volume energy + energy of velocity along the pipe.

Before leaving the pipe the heat energy has been drawn upon to increase the volume and also to increase the velocity of the steam, while at the same time the friction has been absorbing a part of the energy of velocity and returning it in the form of heat energy. So, if the pipe could be perfectly insulated all the energy entering the pipe would be delivered at the other end.

Editorials

The Governors and Conservation

Once in every seven years the human body completely changes. We do not know how anyone knows that, but the wise ones claim it is so, and as we cannot prove that it is not, we have to accept it. But, granting that it is true, the human body has nothing on the body of governors of these sovereign states which for seven years has been assembling annually and, in that time, if it has not entirely changed its physical makeup, surely has completely changed its mind.

The very purpose of the original conclave was to arouse the people of this country to the dwindling supply of our natural resources and set in motion the machinery of government to the end that all possible wastes might be eliminated. "Conservation of our natural resources" was the keynote of the convention and became the popular slogan almost immediately. Such is our naturally buoyant nature as a people, however, that we just cannot keep ourselves indefinitely concerned about the welfare of future generations, and so after seven years the "Conservation Congress," as it had come to be known, proves to be almost the opposite. Sentiments were there expressed, as mentioned in the report of the meeting on page 761, that would have been set down as rank heresy had they been aired at the earlier conferences.

The only conservation that seemed to appeal at this particular gathering was that of state rights. The Western governors, especially, obviously preferred state to federal control. As to which is the better, so far as natural resources are concerned, is a question which we are not prepared to discuss further than to suggest that whichever one will make for the greatest solidarity of these United States as a nation would have our preference.

The history of Europe, particularly that at present in the making, proves the need of larger countries since now several have to unite for mutual protection against a common enemy. That which tends to separate our states by provoking jealousy and discord would tend toward the unhappy condition of affairs that is common to the Balkan States. Also, we should prefer that form of control which would be least approachable, supposing there were any unscrupulous combinations seeking to influence the legislators to favor them in the distribution of rights to the natural resources. In other words, we should favor that form of control which best conserved the benefits accruing from the natural resources to the people as a whole.

The ordinary consumers of electricity in St. Louis are still paying the same price for current that they paid before the Keokuk plant was built. The saving they should have enjoyed has become the profit of a few—a little gift from the Government, which probably will not repeat the error. Let us have no more Keokuks!

But, to return to the subject of conservation, we concur in the evident attitude of the governors as a whole that true conservation is not hoarding but wisely using, without wasting, the natural resources to the greatest good of the greatest number.

Hail, Calorigene!

Save your ashes. There is another scheme on to burn them. This time it is "Calorigene," and news of it comes out of the North. The *Ottawa Free Press* hails it as a "timely discovery," and says it will burn up seventy-five per cent. of the ash and effect a saving of twenty-five to fifty per cent. of the coal, in which case from one- to two-thirds of the coal would seem to need to be ash, unless the ash has more heat value than the coal itself.

The timeliness of the discovery, or of the announcement, to our mind, lies in the fact that the public has just about had time to forget Doctor Hoy and the Cobbler of Scranton. It was about seven years ago that they set the engineering world by the heels with their announcement that a solution of salt and oxalic acid would make a fuel bed out of an ash heap. Thousands of engineers all over the country set out to burn up their ashes. The Board of Education of New York City laid in a stock of the chemical and made the janitors use it. Quite a bit of unburned carbon which had found its way into ash barrels was saved by the second burning, but in the last analysis it was found that such of the so called ash as was burnable was carbon and would burn without the aid of the cobbler's compound, and such as was really ash was beyond resuscitation. The cobbler presumably went back to his last and the doctor who financed the scheme shot himself.

Low-Priced Goods

"Quality first" is an excellent slogan, but what is quality?

The best quality of babbitt metal for a main bearing may be the most highly priced brand. If it is to be used to fill a blowhole in a casting, type metal may be the best as well as the cheapest. The most expensive cylinder oil may be none too good in the cylinder, but for the line shaft, where it is expected to run cool, it may be the most expensive. Georgia Creek coal may be the best as well as most expensive, but if there is a pile of sawdust handy that you cannot float down stream it may be cheaper to burn that instead.

The greatest difficulty, however, comes in the fact that many things, from globe valves to engines, masquerade as of high quality when they are not. Finish may be substituted for quality, both of material and workmanship.

That there is a legitimate field for cheap goods in all these lines cannot be denied. In construction work, where temporary plants are used, and where the salvage on removal is far from complete, no matter what material is used; where the work is in the nature of experiment, or where the conditions are such that acidity in the water must be tolerated for a time—in these and in many other instances a cheap grade of material is the most economical. The difficulty is to prevent this material masquerading as good material at low cost.

Unfortunately, many have an obsession that all manufacturers make a profit of several hundred per cent. on their products. These misguided people honestly believe that it is possible to buy at half the price of the real article and still leave the manufacturer profit enough to continue to do business. If such men would only keep track of the percentage of failures of manufacturers, they might see that they are mistaken. As it is, they make an easily gullible section of the purchasing public that is exploited by the more or less irresponsible dealer in "just-as-good" goods.

⁂

The Periodical Overhaul

How long has it been since each or any machine under your charge has been overhauled? Some have the habit of letting everything go so long as it runs and do not think of repairs or renewals until there is an absolute breakdown. The most careful engineer cannot avoid all mishaps and, no matter how alert he may be to the first signs of weakness or improper conditions, he will occasionally have troubles of one kind or another. Nevertheless, it is a safe wager that the man who looks ahead to avoid such things will have less of them than he who waits to act under compulsion. Herein lies the value of the periodical overhaul.

This is not to say that once a year everything should be gone over, although this is a better rule than none at all, but, at certain intervals greater or less in length, depending on the nature of the apparatus, everything should have a thorough examination, internal as well as external. This goes beyond the simple tests as of safety valves or engine stops, which, of course, should be tried at least once every day. We refer rather to the actual taking apart of every piece of running equipment until all vulnerable parts are exposed. Scored cylinders, broken or ill-fitting rings, worn bearings, clogged oil holes and countless other little things may exist for some time before they make themselves evident in the routine operation. They may come about so gradually that change of sound in the running is not sufficient from day to day to disclose their presence. A crack in a concealed part may mean real danger if not discovered in time and the periodical overhaul may reveal it before it has done any mischief.

The overhaul naturally includes, first of all, a thorough cleaning, but some make that practically the full extent of the work. Others will go far enough to search out and adjust, fit or renew such members as show too much wear and probably also replace parts that show serious effects of corrosion. The ultracautious will separate all the pieces that are not riveted or otherwise joined in such a way that it would be inadvisable to disturb them, and measure or test them with a hammer, as the case may be, to see if they are worn or distorted or in any way unsound.

Even if an overhaul proves to have been unnecessary, it is instructive at any rate to those who take part in it, and is the best of training for the whole force. Notes taken and retained of the findings may prove of considerable later value.

Edison Rate Case Postponed

Just at a time when the public, after two or more years of patient waiting, had reason to expect an early decision in the Edison rate case, comes the announcement that the Public Service Commission has granted a rehearing, based on the contention of the company's attorneys that insufficient information has been called for and submitted. Whether this contention is well founded we are not prepared to say; that it should have taken the commission two years to find this out is inexcusable.

Commenting on this case three weeks ago, we sought to give the commission the benefit of the doubt, and ascribed the slow progress to a desire to be thorough and omit nothing which would be pertinent to the establishment of equitable rates. That we spoke too soon is apparent.

Where the New York commission has so miserably failed to accomplish results similar commissions have been highly successful in other states, notably Missouri (see page 761), where in six months two important decisions were rendered in which a complete readjustment of rates has been ordered. In each of these cases, all factors entering into the cost of production were thoroughly investigated. These, although less in scope, were not essentially different from those involved in the Edison case. When it is recalled that the salaries of the Missouri commissioners are five thousand five hundred dollars each per annum as against fifteen thousand dollars for the New York commissioners, one does not have to figure long to judge in which state the public has made the better investment.

⁂

If the advocates of municipal ownership are prone to be overenthusiastic and visionary, its opponents do not always display a highminded disposition to get at the truth, whichever side it hits. Cleveland, Ohio, has gone further in the direction of operating its own public utilities than any other American city, and has recently completed the largest municipally owned electric-light station in the country. Mr. Ballard, the engineer, estimated that such a station could be made self-supporting with a maximum charge of three cents per kilowatt-hour. The first three months' operation seemed to justify the estimate of operating expenses upon which this claim was based, but the station has been running, naturally during the period of inauguration, at a very low load factor, not more than one-quarter of the load for which it is designed being carried. This has, of course, made the cost per kilowatt-hour, including the fixed charges, high, whereupon the publicity agent of the Antis gets busy and floods the country with accounts of "another municipal-ownership fizzle," telling in apparent sincerity how the current at Cleveland is costing four to five times as much as the engineer estimated.

And the funny and exasperating part of it is that engineers who ought to know better swallow the story, bait, hook and sinker.

⁂

The engineer (?) who hangs a weight upon the lever of the safety valve has been outdone by the man who put the weight of a New York sidewalk on his, by wedging the valve against it. The wedge held, but the boiler head did not.

Correspondence

What Caused the Break?

As to the broken crankshaft described by E. E. Merrill, on page 613, Oct. 27, it is very evident that there was a sudden abnormal load on the generator.

Cylinder No. 2 was probably firing at this same instant and as ammonia compressors usually have heavy flywheels, their momentum, added to the force of the explosion in No. 2 cylinder, would oppose the sudden retarding force due to the short-circuit and tend to localize the strain at No. 2 crank at about the place the break actually occurred.

The shaft may have had an unsuspected flaw of long standing. Again, as the babbitt was nearly all gone from bearings Nos. 1 and 3, if the engine had been running in this condition there might have been continued weakening due to the loose bearings. It would be interesting to know whether there was any jump in the shaft when No. 1 fired and what apparatus there was to protect the generator from overload.

EARL PAGETT.

Coffeyville, Kan.

As the shaft ran on five bearings and the break occurred between Nos. 2 and 3, it being found that the babbitt was wiped out of bearings 1 and 3, it seems to me that the power impulses distorted the shaft until it crystallized and weakened. It is evident that the shaft was held rigidly between bearings 4 and 5, so that it bent at every impulse until it broke. This frequently happens on high-speed automobile motors.

FORREST R. CARPENTER.

Salmon Falls, N. H.

[A high bearing between two low ones will surely cause a shaft revolving in them to break in time. This method is sometimes used to test material.—EDITOR.]

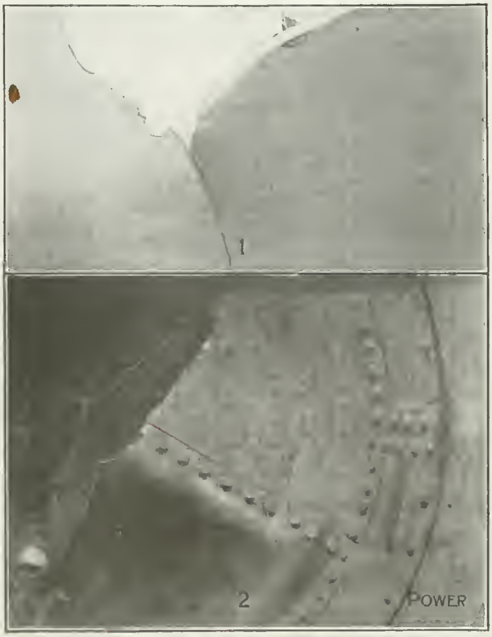
⁂

First Boiler Explosion in Atlantic City

On the night of Sept. 29, a boiler explosion occurred in Atlantic City, N. J., which is said to be the first in its history.

While this is a good record, it is more from good luck than any other cause, for there are many boilers there which have never been inspected. Many are insured and receive regular inspections, but there is no assurance that the boilers are being kept in a safe condition.

The wrecked boiler was a 10-hp. vertical, 44 in. diameter by 12 ft. high, with shell plates $^3/_8$ in. thick, having double-riveted lap-seam longitudinal joints. The furnace, 40 in. diameter by 40 in. high, made of $^5/_{16}$-in. sheets, was supported by only two rows of $^3/_4$-in. stay-bolts. The furnace sheets collapsed, Figs. 1 and 2, the cause being the corrosion of the stay-bolts, which had wasted to $^1/_4$ in. at the furnace sheet. The safety valve was set at 40 lb., and just previous to the explosion the gage showed 30 lb. Probably transporting the boiler broke some of the stay-bolts (it had been moved lately), owing to their greatly reduced area, and the furnace sheet had bulged gradually, thus straining those stay-bolts still holding.



FIGS. 1 AND 2. SIDE SHEET OF FURNACE

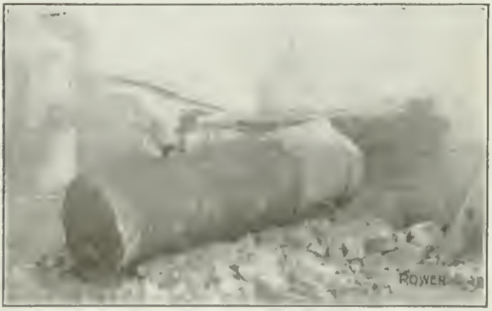


FIG. 3. BRICK WALL CRUSHED

The sudden release of the water and steam forced the boiler upward through the roof, and it landed on a wagon shed. That it went up a considerable distance is indicated by the broken wall where it rested after falling, Fig. 3, five or six feet of which was crushed as though made of cardboard.

One lesson from this accident is the necessity of hollow stay-bolts. A leaky stay-bolt can readily be renewed at a cost far less than a new boiler and possibly a suit for damages. In the case mentioned above one life was lost.

Atlantic City has an engineers' license law, but this plant had managed to elude the law and had no licensed man in charge.

R. W. Robinson.

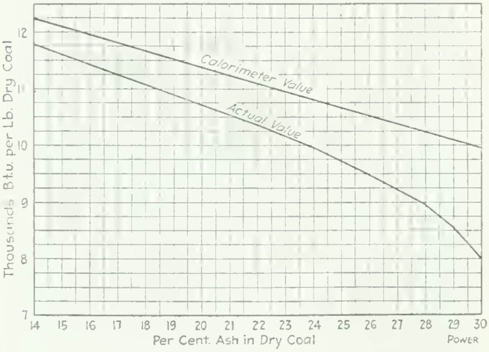
Germantown, Penn.

⁂

Ash Influence on Fuel Value of Small Anthracite Coal

There were two errors in my article under the above caption in the Sept. 22 issue.

The first occurred in Fig. 2, in which the marginal line read "B.t.u. per thousand pounds dry coal" instead of "thousands B.t.u. per pound dry coal," as submitted with the chart.



Reproduction of Mr. Philo's Fig. 2.

I made the second error in the formula for loss of combustible in copying from my notes. The formula should read:

$$\text{Per cent. total combustible lost} = \frac{(\text{per cent. ash in dry coal}) \times (\text{per cent. combustible in dry refuse})}{(100 - \text{per cent. ash in dry coal}) \times (100 - \text{per cent. combustible in dry refuse})}$$

Frank G. Philo.

New York City.

⁂

Recovery of Gas-Engine Waste Heat

In the Oct. 6 issue appeared an article on the "Recovery of Gas-Engine Waste Heat." The writer some time ago secured a patent on the same system for generating steam, but at less than atmospheric pressure. In a small engine, with thin cylinder walls, using natural gas, it is possible to reach high temperatures without premature ignition, but in engines with thick walls and using gasoline, illuminating or producer gas, the temperatures have to be kept down, and in vacuum heating systems temperatures below 210° are desired. The outfit consists of a small centrifugal pump circulating water through the jackets and a closed tank higher than the engine in which steam is generated. Gravity makes the pressure in the jackets so high that no steam is generated there.

The Westinghouse Machine Co. ran some tests on such an outfit with the following results:

24.9 per cent. converted into work.

35.1 per cent. obtained from the jackets.

23.8 per cent. obtained from the exhaust in a form suitable for heating. The engine was 200 hp. and used 10.6 cu.ft. of natural gas per hour, having a heat value of 966 B.t.u. per cu.ft.

E. S. McClelland,
Engineer Gas Engine and Producer Dept.,
Westinghouse Machine Co.

East Pittsburgh, Penn.

⁂

Shutting Off Cooling Water Too Soon

Where bearings are water-jacketed and in cylinder jackets where it is necessary to use cooling water carrying a large amount of scale-forming matter, the water should not be shut off too soon after the machine has been stopped.

Water left in the coils or jacket will soon reach a temperature at which it will give up lime or scale-forming solids; during the period of operation the temperature of discharge water is usually below this point. It can be readily seen that a machine operating intermittently could have its cooling coils sealed up worse than one operating continuously. In some localities the well or spring water will begin to precipitate as low as 106 deg. F. Trapped jacket water may reach a temperature of 150 deg. F. in a few minutes after stopping the flow.

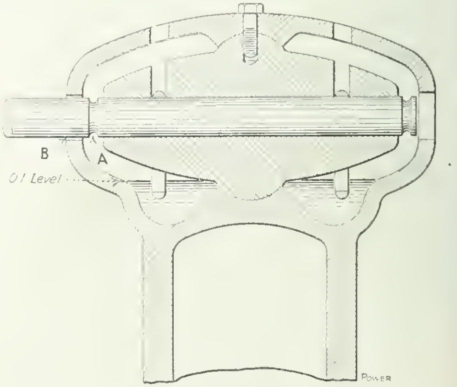
John F. Hurst.

Louisville, Ky.

⁂

Case of Oil Throwing

A second-hand 75-kw. motor was overhauled and set up to run as a generator. After starting, it was found that oil was flying from the shaft into the armature winding.



Section through Bearing Showing How Oil Leaked Out

The construction of the bearing was as shown in the sketch, and it was a puzzle to know how the oil got by the oil guard *A*. The cap was removed and an examination made. Everything was apparently as it should be, but on starting again the same condition prevailed. The cap was again removed, the oil wiped from the shaft and the armature turned over by hand. A small trace of oil showed faintly on the shaft outside the groove *A*. It finally developed that the clearance between the shaft and the bearing shell was so small that the oil, running down from the top half of the shell, found its way along the edge *B*, and was picked up by the shaft and thrown out. The bearing pedestal was taken off and the shell cut down slightly and beveled inward to a feather edge. After assembling again and starting, the oil remained in the bearing.

Earl Pagett.

Coffeyville, Kan.

Leaky Check Valve

A laundry boiler was fed from the city main as the pressure in the mains was usually 25 lb. above that in the boiler. One day the fireman noticed the water gradually disappearing from the glass gage, and the wider the valve was opened the more rapidly the water went down.

The plant was shut down and the fires pulled. The feed valve having been left open, the water came back in the glass at 60-lb. steam pressure. It was learned that the street pressure had been reduced and that the pressure in the boiler had forced the water out into the street main because the check valve leaked.

Edward T. Binns.

Philadelphia, Penn.

Lap of Girth Seams of Steel Stacks

It is sometimes questioned whether the girth seams of a steel stack should be made with the upper sheet lapping over the lower like Fig. 1 or with the upper sheet inside of the lower as in Fig. 2. The disadvantage claimed for the construction like Fig. 1 is that soot and ashes lodging on the edge *A* find their way through crevices in the joint and are washed down the outside by rain, causing the paint to be removed and the stack to rust from the outside. This is likely to occur with stacks made of material too thin to be calked. On the other hand, a stack made with joints like that shown in Fig. 2 is more likely to become rusted out at the girth joints by rain water entering at *B*.

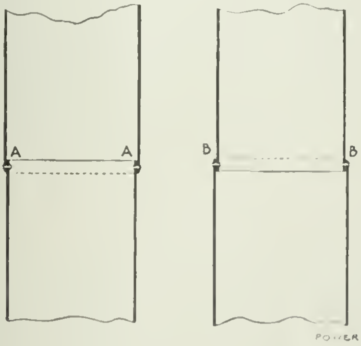


FIG 1 FIG 2

Methods of Lapping Girth Seams of Steel

Several years ago we had a stack made where each course entered the course below it like Fig. 2, and we got longer service out of this stack than the one which it replaced, which had joints made by lapping the upper over the lower courses like Fig. 1.

Later, we installed a new boiler with a new steel stack made as in Fig. 2 and got only about two years' service out of it, though it should be stated that we used steam jets for smoke consuming under this boiler. This may have had something to do with its short life.

I believe the main thing in a steel stack is to get good material and have the joints made tight and the stack painted often. The rust and soot gathered at the joints should be cleaned off frequently, otherwise painting will be of little purpose in prolonging the durability of the stack.

H. A. Jahnke.

Milwaukee, Wis.

Tests of Substitutes for Gasoline

The article entitled, "Tests of Substitutes for Gasoline," in the Oct. 20 issue, is worthy of commendation, not only because it gives the results of carefully made tests in an almost virgin field, but also because the subject is of commercial importance. The wide sale of agricultural engines and tractors adapted to the use of kerosene instead of the more expensive gasoline is the best possible proof of the demand for such machines, and anything which throws light on the problems involved in the use of kerosene is worth while.

In a footnote on the first page, the following statement is made: "Natural gas contains some methane (CH_4), pentane (C_5H_{12}), hexane (C_6H_{14}), etc., all of which are liquid at ordinary temperatures after they have been removed from the gas." Part of this statement is erroneous.

It is true that natural gas contains methane, propane and hexane. Methane often forms 96 per cent. or more of the mixture commonly called natural gas; on the other hand, pentane and hexane occur only as traces in most natural gas and in slightly larger quantities in the varieties of gas drawn from oil wells. It is not true that methane is liquid at ordinary temperatures after being removed from the gas.

The critical temperature of methane is —95.5 deg. C. (—139.9 deg. F.). Recalling that the critical temperature is that above which a gas cannot be liquefied, it is obvious that methane could not possibly exist as a liquid at ordinary temperatures even under the highest pressures. Furthermore, methane boils under atmospheric pressure at a temperature of —164 deg. C. (—263.2 deg. F.), so that if it existed in liquid form under atmospheric pressure, it would boil away completely at more than 300 deg. F. below ordinary temperatures.

With pentane and hexane, the case is different. The critical temperature of pentane is +194.8 deg. C. (382.64 deg. F.); that of hexane is +250.3 deg. C. (482.54 deg. F.). Obviously, both of these materials could exist as liquids at ordinary temperatures because such temperatures are well below the respective critical values. The respective boiling temperatures at atmospheric pressure are 36.2 deg. C. (97 deg. F.) and 69 deg. C. (156.2 deg. F.). From these values it is evident that pentane can exist as a liquid exposed to the atmosphere at moderate temperatures, but that it would boil away on a hot day; while hexane is a more stable liquid and highly volatile, it would not boil at any natural temperature. As a matter of fact, hexane is just about as volatile as the very highest grades of gasoline, while pentane is too volatile to be handled in liquid form excepting under the most unnatural conditions.

All of the members of the paraffin series, to which methane, pentane and hexane belong, are mutually soluble. Therefore, it is probable that small quantities of methane would be held in solution in any liquefied hexane procured from natural gas, in just the same way as many gases are held in solution in water and similar liquids. This might be regarded as liquefaction, but it is not the sort commonly meant by the expression "liquid at ordinary temperatures."

In the article under discussion, the manufacture of gasoline by the cracking process is briefly discussed. It might be well to note that gasoline made in this way is very different from that made by the process of fractional distillation. Most tests applied to gasoline are of a physical nature and generally consist of a determination of the gravity and the making of a fractional distillation. Both kinds of gasoline can be made to appear identical under these tests, but chemically they are very different.

Gasoline obtained by the fractional distillation of a paraffin-base oil consists almost entirely of members of the paraffin series. Gasoline obtained by cracking heavier paraffins consists of a mixture of paraffins, or saturated hydrocarbons, with unsaturated and with ring hydrocarbons. The chemical properties are therefore different, and since combustion phenomena depend on chemical properties, the characteristics in this respect are also different.

Little experimental work has been done along these lines in the case of gasoline, but kerosenes made by cracking have been carefully compared with those made by fractional distillation and different properties have been observed. Cracked kerosenes exhibit a greater tendency to burn with a smoky flame and to deposit carbon than do uncracked kerosenes. They also form more evil-smelling compounds during the combustion process and, in general, act like a less pure and less tractable material. It is probable that differences of the same kind, though possibly not of the same extent, also exist between gasolines made by the two processes. If this be true, cracked gasoline should behave somewhat like kerosene in an engine cylinder and many claim that cracked gasolines cause more rapid and more plentiful deposition of carbon in cylinders than do fractionally distilled gasolines.

The engine used in making the tests described in Professor Moyer's article was governed by the hit-and-miss method. By far the greater number of small engines in use are governed in this way, and the demonstration that kerosene can be successfully used in such engines is important. On the other hand, attention should be called to the fact that kerosene-burning engines should, when possible, be governed by throttling.

Hit-and-miss governing causes great fluctuations in cylinder-wall temperatures and in the proportions of the mixture, as has been demonstrated by means of thermocouples and indicator diagrams. It so happens that an engine using gasoline can operate satisfactorily despite such erratic variations; the case is very different with kerosene.

The performance of an engine on kerosene may be described as inelastic in comparison with its performance on gasoline. It can be made to operate, but it is far more sensitive to small misadjustments. A slightly cooled wall causes the deposition of liquid kerosene. A slightly cooled mixture prevents the completion of vaporization and leaves some of the kerosene suspended in the clearance space in the form of an incombustible fog. A slight overdose of kerosene immediately causes signs of trouble, while a gasoline engine can be operated for hours with 50 per cent. excess of gasoline without displaying any marked symptoms.

Since throttle governing tends toward gradual changes and therefore more steady conditions, it is possible to obtain better operating results with kerosene when this method is used. This is particularly true when the water injection is put under the control of the governor. With a throttle-governed engine, water injection is not ordinarily required at a load below 40 to 50 per cent. of rating, though very small quantities may be injected advantageously at the lower loads. As the load increases above 50 per cent., more and more water is required, until at maximum capacity a volume of water anywhere between 50 and 100 per cent. of the volume of the fuel is used.

Compare such operation with that of the engine used in the tests. The water was injected through a hand-controlled needle valve and must of necessity have been the same in quantity immediately after a missed cycle as after several hits. It is obvious that a cylinder already cooled by several misses does not require further cooling by water injection. As a matter of fact, it is possible, though not probable, that the engine under test was so operated that water was even admitted during missed cycles.

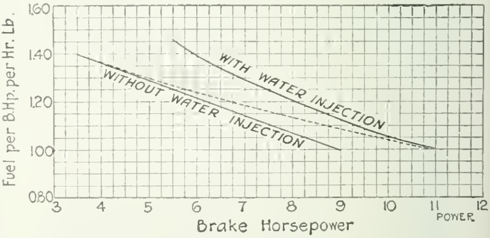


Fig. 1. Assumed Fuel-Rate Curve for Throttle-Governed Engine

In view of this, the curves and data given by Professor Moyer should be regarded only as applying to an engine of the type tested when operating under similar conditions, and the conclusions drawn should not be generalized and applied to all forms of kerosene-burning engines with water injection.

It is probable that a throttle-governed engine operating on kerosene will give about the same thermal efficiency at light loads as did the hit-and-miss governed engine in these tests when operating at corresponding loads. This is not theoretically correct, but practice is at variance with the simpler theory in this regard. It may be assumed further that at maximum load the throttle-governed engine with water injection is practically the equivalent of the hit-and-miss governed engine with water injection. With these assumptions, the fuel-rate curve of a throttle-governed engine can be approximated from the data given by Professor Moyer. Such a curve is shown dotted in Fig. 1, the full lines representing the curves of Fig. 1 in the original article. It will be observed that this new curve is almost a straight line coinciding at light loads with that of a hit-and-miss engine without water injection and at heavy loads with that of a hit-and-miss engine with water injection.

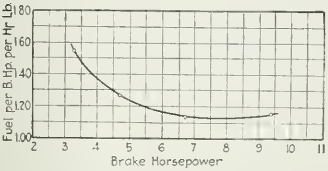


FIG. 2. CHARACTERISTIC FUEL-RATE CURVE

The characteristic fuel-rate curve of an internal-combustion engine is similar to that shown in Fig. 2, which is a reproduction of that in the original article. This characteristic curve is markedly convex and is very different in shape from that shown dotted in Fig. 1 as the probable curve of a throttle-governed engine with properly controlled water injection. The straightness of the proposed curve is explained by the fact that water injection raises the consumption per brake horsepower at the higher loads in the same way as occurred at all loads in the tests recorded. It should be noted at this point that one of the numerous functions of injected water is the cooling of the charge in a way and at a speed which it is impossible for jacket water to imitate. It should also be noted that the internal surfaces of the engine cylinder should be operated at the highest feasible temperature when using kerosene, in order to prevent the deposition of liquid kerosene on those surfaces. These observations point to the possibility and the desirability of operating engines of this type with higher jacket temperatures than is customary with gasoline engines, particularly at high loads when the quantity of water injected is great. Such operation would decrease the quantity of heat lost to the jacket and would probably decrease the fuel consumption per unit at high loads. This would, in turn, make the fuel-rate curve approach nearer to the characteristic shape previously mentioned.

It is hoped that these tests may be continued and extended to cover other sizes and types of engines. It is suggested that the use of heated air might also be compared with the use of a heated carburetor as used in these tests and that the injection of water into the suction pipe might be compared with injection of water directly through the wall of the cylinder. It would also be well to investigate the effect of the temperature of the water injected, as there is a wide range of temperatures available in any operating engine. The writer has always believed that the higher the temperature of the water, the better. In fact, it seems reasonable to believe that the injection of steam would give even better results than the injection of hot water.

C. F. HIRSHFELD.

Detroit, Mich.

Spacing Flange-Bolt Holes

Referring to the query from "W. F. L." in the Aug. 4 issue, regarding spacing of holes on a circle by the use of dividers, I wish to call attention to the spacing tables given on pages 67, 68 and 69 of *Machinery's Handbook*. For the example given of nine holes in an 18-in. bolt circle, on page 69, we find for a 9-in. circle and nine divisions a chord length of 3.078 in., or for the 18-in. circle the setting would be

$$3.078 \times 2 = 6.156 \textit{ in.}$$

This value can readily be checked from the value of the sine of half the arc. With nine holes the arc between holes will be

$$\frac{360}{9} = 40 \textit{ deg.}$$

The sine of ($\frac{40}{2} =$) 20 deg. is 0.342. Hence the chord for an arc of 40 deg. on a circle of unit radius will be 0.684 and for one of 9-in. radius

$$0.684 \times 9 = 6.156.$$

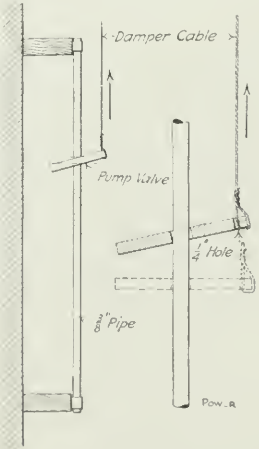
G. W. PARK.

West Allis, Wis.

[This is interesting as a mathematical method, but the one given on the "Inquiries of General Interest" page is more practical, requiring no handbooks or tables. Dividers cannot be set directly at exactly 6.156 in., so it would be a case of "cut-and-try" anyway, and a draftsman would have the trick done graphically while one was looking up a table in a book.—EDITOR.]

Simple Hand Damper Regulator

All who have tried know how hard it is to get close damper adjustment with any hand regulator employing a system of notches into which the damper cable or wire is hooked by a catch.



ADJUSTER FOR HAND-OPERATED DAMPER

I recently installed in my plant a device, the principle of which I took from the carbon clutch in the ordinary arc lamp. It is simple in construction, easy and sure in its operation and can be adjusted to give any desired reading of the draft gage.

The necessary things are a piece of ⅜- or ½-in. pipe, an old rubber pump valve four or five inches in diameter and about ⅝ in. thick, with a hole at the center somewhat larger than the outside diameter of the pipe, a couple of pieces of wood, a pair of pipe straps and a few small screws.

The accompanying sketches show how the parts are assembled.

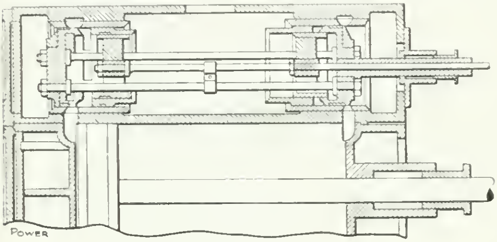
W. G. Greenlees.

El Campo, Texas.

⁂

Bent Rods Measured with Wire

I had an accident recently with a Buckeye engine of 200 hp. The nuts came off the rods on the inside of the main steam valve, and the rider valve was left to act at its own option. It did not act very well, shutting the engine down with 80 lb. of steam pressure on. These rods were bent so that it was difficult to remove them and to get their exact length. I bent some wire solder, which is flexible, to follow the shape of the bent rods, and in that way got the proper length of the rods.



Nuts Came Off Long Rods

William Burley.

Xenia, Ohio.

⁂

Repairing Commutators

Having lately noticed in Power a method of repairing holes in commutators by filling them with paste, I shall describe a method used with good results on 600-volt railway converters, which are at times heavily overloaded.

Where the hole is at the front end of the commutator, take a hacksaw blade the thickness of the mica and saw down between the bars, being careful to saw straight, until the burned mica is cleaned out and the bottom of the cut is free. Now take some sheet mica of sufficient thickness to press it in with the fingers and fit as tightly as possible without buckling. Be sure that the edge of this patch is straight. Having fitted the patch in the cut, remove it and coat it, as well as the inside of the slot, with shellac.

Now press the patch in firmly and, with a screwdriver and tack hammer, gently calk the bars on each side of the patch, and on top at the end of the bar, but not quite to the ends of the patch. Cut off the patch by cutting sideways with a sharp knife and smooth with sandpaper. The main thing is to get a good fit at the bottom; if this is not done, the current will jump through and again burn out the mica. With a good joint at the bottom, the calking will hold the patch in place and the job will last indefinitely. I have some commutators repaired in this way that have been running three years.

Trouble can often be prevented by rounding the corners of the bars to a radius of about ⅛ in., as a square corner leaves a sharp point and invites the current to jump across.

H. W. Ginaven.

Springfield, Ohio.

⁂

Depolarized Generator

Three separately excited, two-phase, 220-volt, alternating-current generators of different sizes and speeds were connected to a switchboard with two sets of busbars and a number of double-throw switches. No. 1 generator leads connected to one set of busbars and led to one side of the switch contacts. No. 2 leads connected to the other set of the busbars and supplied current for the other side of the switch contacts. The power lines were connected to the middle contacts. The leads from No. 3 generator were connected to the middle contacts of a double-throw switch and could be made to supply either set of busbars. It is evident that only two generators could be in use at one time.

One evening on starting No. 3 machine no current could be generated. After thoroughly looking it over and finding nothing wrong we came to the conclusion that the day engineer had been operating No. 3 on No. 2 side while No. 2 was down, and in starting the latter forgot to change the control switch for No. 3 to the other side (No. 1 being down) before the current had passed through No. 3. We therefore reversed the field leads on No. 3 and started up, and it generated immediately. The engine was stopped, the leads connected in correctly and we had no further trouble.

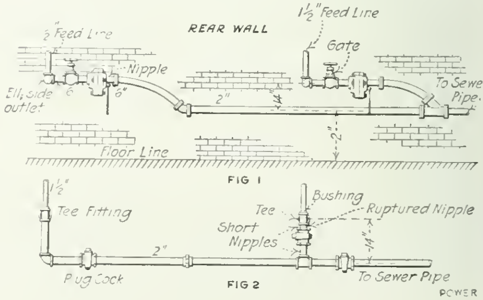
Herbert Holroyd.

Philadelphia, Penn.

⁂

Change in Blowoff Piping

When I took charge of this plant one of the blowoff lines leaked. Fortunately, it occurred near the end of the week, and a clamp and a piece of sheet packing held it until Saturday afternoon, when the boilers were emptied. The following day I replaced this line, as shown in Fig. 1, dispensing with the short nipples and permitting of an easier flow of water from the boilers.



Improved Blowoff Connection

Fig. 2 shows the old line with short rigid connections.

Frederick L. Johnson.

Paterson, N. J.

Inquiries of General Interest

Temperature of Feed Water with Double-Tube Injector—Can water be fed into a boiler with a double-tube injector at a temperature greater than 212 deg. F.?

S. C.

Double-tube injectors are made for locomotive service, which are adapted to feeding against 200-lb. boiler pressure, and by reducing the water supply the temperature of the feed can be raised above 212 deg. F.

Pitch of a Gear Wheel—What is meant by the term "pitch" as applied to gear wheels?

L. A. M.

The term refers to the spacing of the teeth. Circular pitch is the distance from the edge of one tooth to the corresponding edge of the next tooth, measured along the pitch circle. Diametral pitch is the number of teeth to each inch of diameter of the pitch circle, therefore circular pitch = 3.1416 ÷ diametral pitch, or diametral pitch = 3.1416 ÷ circular pitch.

Relative Water Level in Connected Boilers—Where two or more boilers discharge their steam into the same header, is it practicable to maintain the same or a relatively uniform water level in the boilers by connecting together their blowoffs and feeding into one boiler?

H. B.

For discharge of water to take place from one boiler to another through connected blowoffs or a similar connection, there must be enough difference of water level to equal the head required for the velocity of the flow and for overcoming the friction. Therefore, when the boilers are steaming, the same level of water in the different boilers could not be maintained by feeding one boiler and connecting together the blowoffs of the boilers.

Impurities in Feed Water—What are the principal scale-forming impurities in feed waters, and what are the temperatures at which they are thrown down by heat?

F. W. G.

The impurities most commonly present which form boiler scale are calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$), calcium sulphate ($CaSO_4$) and magnesium sulphate ($MgSO_4$). The carbonates begin to deposit when the water is heated to about 180 deg. F., and by the time it has reached 212 deg. F. the greater part of the carbonates will be deposited, and all the carbonates will be deposited when the water has attained a temperature of about 290 deg. F., which is the temperature of evaporation of water under a gage pressure of about 43 lb. per sq.in. The sulphates remain in solution until a temperature of about 300 deg. F. (52.3 lb. gage pressure) is reached, when they become insoluble and settle.

Boiler Efficiency vs. Efficiency of Boiler and Grate—What is the difference between "efficiency of the boiler" and "efficiency of the boiler and grate?"

H. B. G.

(1) Efficiency of the boiler =

$$\frac{\text{Heat absorbed per pound of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

being the ratio of the heat absorbed in generation of steam to the heat contained in the combustible that was actually burned, irrespective of how much may have dropped through the grate.

(2) Efficiency of boiler and grate =

$$\frac{\text{Heat absorbed per pound of coal}}{\text{Calorific value of 1 lb of coal}}$$

being the ratio of the heat absorbed in generation of steam to the heat contained in the coal used

The first is the one understood when the words "boiler efficiency" are used without qualification, and is of value in comparing relative performances of boilers apart from the particular kind of grate used; the second is of value in comparing performances of different kinds of fuels, grates, etc., used with the same boiler

Steam Required for Warming Air—How much steam would be required if supplied and condensed at atmospheric pressure, to raise the temperature of 25,000 cu.ft. of air from 15 deg. F. to 120 deg. F.?

P. H. M.

In condensing, the steam would liberate its latent heat of evaporation, viz.: 970.4 B.t.u. per lb. of steam condensed. A cubic foot of air at 15 deg. F. weighs 0.0836 lb., and the heat required to raise a pound of air 1 deg. F., i.e., its specific heat, is 0.2377 B.t.u. As 25,000 cu.ft. of air at 15 deg. F. would weigh

$$25{,}000 \times 0.0836 = 2090 \text{ lb.}$$

and each pound of air raised from 15 deg. F. to 120 deg. F. would require 0.2377 B.t.u. × (120 — 15) = 24.9585 B.t.u., then the total heat required would be

$$2090 \text{ lb. of air} \times 24.9585 \text{ B.t.u. per lb.} = 52{,}163.265 \text{ B.t.u.}$$

requiring the condensation of

$$\frac{52{,}163.265}{970.4} = 53.75 \text{ lb. of steam.}$$

Sizes of Ports and Pipes—What is the rule for the area of ports and pipes of high-speed engines with strokes 1 to 1½ times the diameter of cylinder and speeds of 200 to 300 r.p.m.?

J. W. W.

The same size of ports would be used for steam as for exhaust. The area of steam pipes and ports would be expressed by the formula

$$a = \frac{AV}{C}$$

in which

a = Area of pipe or port in square inches;
A = Area of piston in square inches;
V = Mean piston speed in feet per minute;
C = Mean velocity of the steam through the port or pipe in feet per minute.

For ordinary piston speeds of about 600 ft. per min., C, in a formula for ports, may be taken as about 5500, hence

$$a = \frac{A \times 600}{5500} = 0.109\ A$$

i.e., the area of ports would be about 11 per cent. of the area of the piston. Allowing for a mean velocity of steam in the steam pipes of 6500 ft. per min., the area of pipe would be

$$a = \frac{A \times 600}{6500} = 0.0923\ A$$

so that the diameter of the steam pipe would be about 0.3 the diameter of the cylinder. For noncondensing engines, the exhaust pipes may be about 0.37 the diameter of the cylinder

Equivalent Evaporation from and at 212 deg. F.—A boiler required 500 lb. of coal for the evaporation of 3000 lb. of water into steam at atmospheric pressure. The feed-water temperature was 160 deg. F., and the coal contained 80 per cent. of combustible. What was the equivalent evaporation per pound of combustible from and at 212 deg. F.?

P. H. M.

The combustible used was 80 per cent. of 500, or 400 lb. of combustible, and the evaporation under actual conditions was

$$3000 \div 400 = 7.5 \text{ lb. of water per pound of combustible.}$$

The temperature of feed water being 160 deg. F., each pound of feed water contained

$$160 - 32 = 128 \text{ B.t.u.}$$

above 32 deg. F., and as a pound of steam at atmospheric pressure contains 1150.4 B.t.u. above 32 deg. F., then for conversion into steam at atmospheric pressure each pound of feed water would have to receive

$$1150.4 - 128 = 1022.4 \text{ B.t.u.}$$

The heat required to evaporate a pound of water from and at 212 deg. F. or latent heat of evaporation at that temperature is 970.4 B.t.u., therefore the factor of evaporation is

$$\frac{1022.4}{970.4} = 1.0536$$

hence, the equivalent evaporation from and at 212 deg. F. was

$$7.5 \times 1.0536 = 7.9 \text{ lb.}$$

of water per pound of combustible

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--VI

Auxiliary Equipment

The present article takes up the proportioning of the various auxiliaries required in a large power plant, and gives a certain amount of working data connected with them.

Condenser

The four general types of condensing apparatus in common use are surface, jet, barometric and atmospheric. Each of these has its advantages under different conditions. The jet condenser is less bulky than the surface condenser, and when the water is of good quality and the oil is thoroughly removed from the exhaust steam, so that the boilers may be fed from the discharge water, it is a desirable type to employ.

The surface condenser is commonly used where the water is of poor quality and where it is desired to use the condensed steam over and over in the boilers, adding about 10 per cent. of fresh water to overcome the corroding effect of distilled water. Here, as in the case of a jet condenser, the oil must be thoroughly removed from the exhaust steam before it is condensed, unless some special form of settling chamber or tank is provided. In the present problem we will assume that the water-supply contains a sufficient amount of impurities to call for a surface condenser.

The weight of cooling water required by a surface condenser, operating under average conditions, is about 35 times that of the steam condensed, when used with a reciprocating engine. The cooling surface in the tubes may be found by the formula

$$S = \frac{WL}{180\,(T - t)}$$

in which

S = Square feet of cooling surface;
W = Weight of steam to be condensed per hour;
T = Temperature of steam at condenser pressure (about 140 deg. for average conditions);
L = Latent heat of steam at condenser pressure, (1013 for a temperature of 140 deg.);
t = Average temperature of cooling water (about 90 deg. for summer conditions).

Substituting the proper values for the present case in the formula, gives

$$S = \frac{(670 \times 18) \times 1013}{180\,(140 - 90)} = 1357 \text{ sq.ft.}$$

The pumps are usually furnished as a part of the condensing equipment and are proportioned for the work by the makers, so that no computations will be made here.

Feed-Water Heaters

Under normal summer conditions the only cold feed to be supplied is the "makeup" water, which, as previously stated, should amount to about 10 per cent. of the evaporative capacity of the boilers. In the winter, when the heating system is in use, the maximum waste of steam to be replaced by fresh water will be the difference between the exhaust from the combined power and lighting engines and that utilized for heating and ventilating. The total exhaust of the main units at this period will be

$$(670 \times 24) + (158 \times 20) = 19{,}240 \text{ lb.}$$

per hour, which increased by that used by the pumps will be approximately 20,000 lb. The amount utilized for heating and ventilating in zero weather was found to be 12,291 lb. per hr., which will, of course, diminish as the outside temperature rises. It will be shown later how to determine accurately the point at which it will be more economical to run the main engine condensing and heat with live steam, but this may be computed approximately as follows. In changing from noncondensing to condensing it was assumed that the steam consumption of the main engine will drop from 24 to 18 lb. per i.hp.-hr., making a total saving of

$$670 \times 6 = 4020 \text{ lb.}$$

of steam per hour from which must be deducted approximately

$$40 \times 18 = 720 \text{ lb.}$$

for pumping the condensing water from the river, leaving a net gain of

$$4020 - 720 = 3300 \text{ lb. per hr.}$$

When the steam required for heating purposes becomes less than this, it will evidently be advisable to run condensing and heat with live steam.

As the steam required for heating varies as the difference between the inside and outside temperatures, it will be diminished for an inside temperature of 60 deg., by one-sixth for each 10 deg. rise in outside temperature, or in the present case

$$12{,}291 \div 6 = 2048 \text{ lb.}$$

With an outside temperature of 50 deg. the steam requirements for heating will be approximately 2045 lb. per hr.; at 40 deg., 4090 lb., and at 45 deg., 3067 lb. It is evident that the economical point of changing from noncondensing to condensing will occur with an outside temperature between 40 and 45 deg.

If the feed-water heater be made of sufficient size to heat the water to replace the exhaust wasted at 45 deg. outside temperature, it will meet all requirements. This is evidently

$$20{,}000 - 3067 = 16{,}933 \text{ lb. per hr.}$$

or 17,000 lb. in round numbers. The required amount of heating or tube surface depends upon the initial temperature of the feed water, the steam pressure within the heater and the velocity with which the water flows through the tubes. With exhaust steam from noncondensing engines, it is customary to allow about one square foot of heating surface for each 90 lb. of water passed through the heater per hour. When exhaust from condensing engines is used, the surface should be increased about 50 per cent., owing to the lower temperature of the steam.

In the present case the heater will do its maximum work when the engine is running noncondensing and will therefore require

$$17{,}000 \div 90 = 188.8$$

or say 190 ft. of tube surface.

Commercial heaters are commonly rated in horsepower, based on $\frac{1}{3}$ sq.ft. of heating surface per horsepower when used with noncondensing engines, and ½ sq.ft. per hp. for condensing engines. This, in the problem under consideration, calls for a heater rated at

$$190 \times 3 = 570 \textit{ hp.}$$

or practically the same as the normal rating of the boiler plant. This long process of determining the size of heater may seem useless in the present case, but under different conditions the result might bear a different relation to the capacity of the boiler plant, and the reader should be familiar with the methods of working out problems of this kind.

The temperature to which the feed water may be raised usually varies from 200 to 210 deg. with steam from noncondensing engines, and from 110 to 120 deg. with condensing engines. This makes it advisable in some cases to provide a secondary heater arranged to take the exhaust from the various pumps, passing the water through the heater supplied with steam at condenser pressure first and then through the second heater taking the pump exhaust at atmospheric pressure. In this way a considerably higher feed temperature may be obtained, depending upon the amount of exhaust at the higher pressure. In the present instance, during the summer, only steam at condenser pressure will be available for feed-water heating and it would evidently be of advantage to utilize the exhaust from the auxiliary pumps in a secondary heater rather than exhaust it outboard. The size of this heater may be estimated with sufficient accuracy as follows:

The exhaust from the auxiliaries commonly runs from 5 to 10 per cent. of that from the main engine. Assuming 8 per cent. as a fair average, this will amount to approximately

$$16{,}000 \times 0.08 = 1280 \textit{ lb. per hr.}$$

calling for

$$1280 \div 90 = 14 \textit{ sq.ft.}$$

of surface or a

$$14 \times 3 = 42 \textit{ hp.}$$

heater, the nearest standard size to which would be 50 hp.

VACUUM PUMP

The size of the vacuum pump for connecting with the return from the heating system may be found by use of the following table, which is abridged from the *Metal Worker* of July 28, 1911:

TABLE 1—SIZE OF VACUUM PUMP

Factor	Size of Pump, In.	Factor	Size of Pump, In.
28,250	6 x 7¼ x 10	49,957	8 x 9¼ x 12
30,600	7 x 7¼ x 10	57,220	8 x 10 x 12
34,410	7 x 8 x 10	60,250	8 x 10 x 14
36,620	6 x 8 x 12	82,397	10 x 12 x 12
43,627	6 x 9 x 12	90,713	10 x 10 x 16

In using this table multiply the number of thermostatic or water-seal valves by 100, and to this add the equivalent square feet of direct radiation. Look for this sum or factor in Table 1 and use the size of pump corresponding. Applying this to the problem at hand, we have a maximum heat loss of 11,922,000 B.t.u. per hr., which requires the equivalent of

$$11{,}922{,}000 \div 250 = 47{,}688 \textit{ sq.ft.}$$

of direct radiation. Thermostatic valves will be required upon each section of each hot-blast heater and upon each direct coil and radiator. Assuming 100 of these to be required, we find the factor to be

$$(100 \times 100) + 47{,}688 = 57{,}688$$

which, according to Table 1, calls for an 8x10x12-in. pump.

RECEIVING TANK AND FEED PUMPS

The size of the receiving tank is usually estimated, and must be large enough to care for any sudden increase in condensation, as when steam is first turned on in the morning, without flooding. For a plant of the size under consideration, a tank 48x72 in. should be of ample size. If two feed pumps are used, each should be of sufficient size to do the entire work not exceeding a piston speed of about 50 ft. per min., or approximately 50 strokes per min., for continuous use. If three pumps are provided, two working together should be able to do the work, which will give a spare pump at all times. A 600-hp. boiler plant will require

$$\frac{600 \times 34.5}{8.3} = 2494 \textit{ gal. per hr.}$$

$$2494 \div 60 = 42 \textit{ gal. per min.}$$

Table 2 gives the capacity in gallons for duplex pumps of different size, based on 20 per cent. slippage and a maximum continuous speed of 50 strokes per minute.

TABLE 2—SIZE OF FEED PUMPS

Size of Pump, In.	Gal. per Min.	Size of Pump, In.	Gal. per Min.
4½ x 2¾ x 4	8	7½ x 5 x 6	40
5¼ x 3½ x 5	16	7½ x 4½ x 10	50
6 x 4 x 6	26	7½ x 5¼ x 10	70

Either the 7½x5x6-in. or the 7½x4½x10-in. pump would do the work required, but perhaps the larger size would be better for continuous service.

BLOWOFF TANK

The size of the blowoff tank depends upon the amount of water it is desired to remove from the boiler at one time. It is usually customary to blow off a small quantity at frequent intervals, and for this purpose it will usually be found sufficient to make the capacity of the tank about one-twentieth that of the total volume of the boiler, neglecting the tubes. If there are two boilers, the tank should be made twice the size, and so on. In a battery of several boilers they will probably be blown off in sections of two or three and the tank may be proportioned accordingly. In the present case we will assume that one battery, or three boilers, is to be blown off at one time. Total volume of three boilers equals

$$28 \times 16 \times 3 = 1344 \textit{ cu.ft.}$$

$$1344 \div 20 = 67.2 \textit{ cu.ft.}$$

which calls for a tank 4 ft. in diameter by 6 ft. long.

VENTILATION OF BOILER AND ENGINE ROOMS

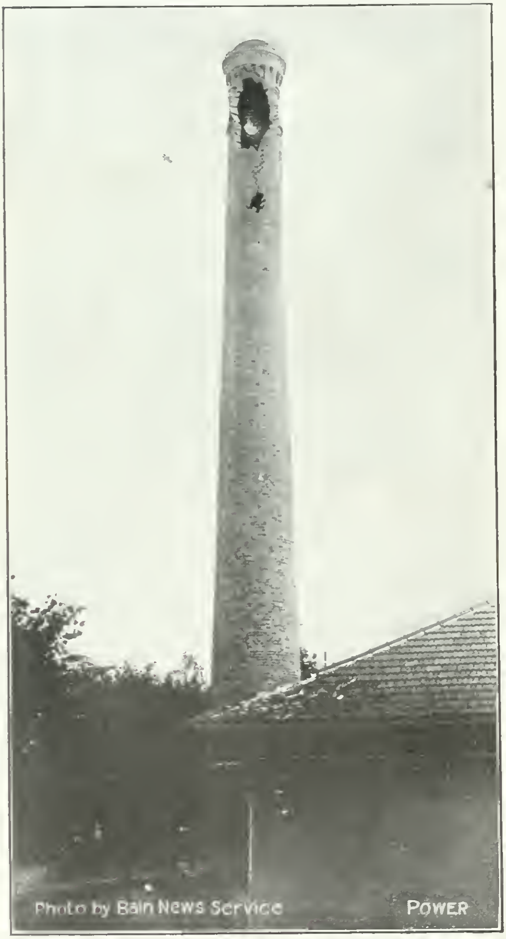
Boiler and engine rooms are usually ventilated by blowing in cool outside air, near or directed toward the floor, and allowing it to pass out through roof openings or monitors.

If the power house is above grade, so that fresh air may be admitted through doors and windows, a fan will not usually be necessary. In the present layout, with the boilers, pumps and condenser below the ground level, it will be advisable to provide artificial ventilation. This will require, for four changes of air per hour, about 7500 u.ft. of air per min. As the subject of fans will be taken up later, we will only state here that from a fan table a 3½-ft. centrifugal fan running at 375 r.p.m. will deliver this amount of air and will require a 3-hp. motor for operating it. No special ventilation will be provided for the engine room, windows and monitor openings being depended upon for this purpose.

⁂

Chimney Hit by a Shell

Fortunately, few of our readers have the opportunity of seeing the effect of a high-velocity projectile on a brick chimney at first hand. Here is the photograph of a chimney at Rheims, France, so damaged. We are indebted to the Bain News Service for this picture.



Chimney near Rheims Hit by German Shell

⁂

Cylinder Lubrication—A heavy cylinder oil should not be fed at the same rate, in drops per minute, as a lighter oil, for there is more substance in a drop of heavy than in one of light oil.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

THANKSGIVING!

In a couple of days we will honor the Pilgrim Fathers to the extent of taking a day off and stuffing ourselves to the ears with turkey and fixin's—and mebbe feel thankful that Thanksgiving Day comes but once a year. Somehow, the last few years, the holidays seem to have slipped their identity tag. Ask your boy Tommy what's Thanksgiving Day. Bet you two bits he'll say: "Gee, dad, it's another day us fellers don't have to go to school."

Most of our holidays mean a lot, though there's many a grown-up Tommy who can't remember if Feb. 12 is Arbor Day or Washington's birthday.

The Pilgrim Fathers were no village cut-ups, we'll admit. That they were a grim lot may have been due to trying to get 968,901 compatriots into the little "Mayflower," if we are to believe the claims of their descendants.

But the P. F. did celebrate the first Thanksgiving Day and it was a good hunch in that it is a reminder that we have slashings of things to be thankful for.

We have escaped the horrors of war, and our country is most wise in its neutrality; the daily supply of B.t.u. at the plant is still in our keeping; the doctor says our baby only has the snuffles—the other five (or 5+ as the case may be) are disgracefully healthy, and we are not well enough to be sick ourselves. Then, again, we can holler for the busy times that are bound to come all the quicker if we but believe in ourselves and our neighbors. Sure we are thankful!

HERE'S WISHING YOU MANY HAPPY RETURNS OF THE DAY! I'LL GET MINE!

"Fight to Keep the Family Home Intact," says a headline. It may be one way to do it, though we doubt if it will work out right. Our own home has remained intact for years chiefly because it took two of us to make a fight. To the trenches for us when we fight!

⁂

Scientist says drowsiness is the result of the nerve cells burning up all their fuel and getting clogged with ashes. Reckon we'll pull our fires and give ourselves the once over. As to the ashes—Mebbe we'll try Calorigene (see our editorial "Hail, Calorigene!" on page 749).

This is a burn-your-ashes-and-get-more-heat-than-from-coal stunt—when it works! Here's how we love Calorigene:

CALORIGENE

It's made us sore and roused our spleen:
No more our mind is gay, serene.
Old Trouble's hit us on the bean—
The reason is, Calorigene!

We've burned the midnight kerosene
And scoured the earth that we might glean
Some help to make our coal bills lean—
Oh, where were you, Calorigene?

Calorigene, Calorigene!
It is quite plainly to be seen
That you have acted doggone mean
To keep yourself so long unseen.

Could we from you one small hope glean,
We'd crown you queen, Calorigene,
If you could save one-half the coal
That's swallered by the furnace hole!

Calorigene, Calorigene!
Say if you're hep to what we mean—
If, when we reach that blessed shore
Where coal and ashes are no more,
Calorigene, if you prove true,
We'll back to earth and stay with you!

Seventh Annual Conference of Governors

At the annual Conference of Governors which was held at Madison, Wis., Nov. 10 to 14, an interpretation of the government's conservation policy was given which differs widely from the conception of this term as held by the majority of the people, at least in the older states of the Union.

The key note of this discussion was sounded by Governor William Spry of Utah when he read his paper on "State Control of Natural Resources."

As developed by this paper and the discussion which followed, there stand out two distinct criticisms of the present policy: First, a criticism of federal ownership and control of the lands, minerals, timber and water powers of the country. Second, a criticism of the idea which seems to prevail in official circles as to what "conservation" is:

The opinion of Governor Spry on the first of these questions is perhaps best expressed by the following quotation from his paper: "Now vast areas have been withdrawn from entry; new and radical departures in the regulations governing the handling of mineral and oil lands have been adopted and the cry is going up for the government ownership of all power sites. Under this policy, the states wherein the public domain as yet lies practically in its virgin state are deprived of that great benefit that accrued as a direct asset to the older states.

"Suppose the government leases mineral, coal and oil lands and water-power sites and remains forever vested of title. Who can estimate the loss in revenue from taxation that will be suffered by the states wherein the valuable resources are located, which revenues have been for years accruing to the older states?"

This is a point on which the Western governors appear to be unanimous. Their contentions along this line were also expressed by Governor Ammons of Colorado to the effect that the resources within the state are by right the assets of the state and not of the federal government.

Also it is claimed that on account of the close proximity to their resources, their knowledge of the conditions surrounding them, and the experience gained by long years of contact with these conditions, the state can more wisely administer these resources than can a bureau of the federal government far removed from the practical problems involved. Great stress is laid on the right of the state to derive revenues from these resources, in the way of taxes, for the support of the state government.

Governor Ammons stated that in Colorado only a trifle more than 25 per cent. of the area of the state was subject to taxation. The remainder is still vested in the federal government and held so that its development is impossible. This throws the burden of maintaining the government, construction of schools and roads and the development of a new state, on a very limited area and a few people, while in time the total area of the state will reap the benefits of the sacrifices of the few. If the state were allowed what it claimed to be its just rights it would develop a policy which would lead to the development and use of its resources and produce additional revenue for the maintenance and upbuilding of the state.

Governor Eberhart of Minnesota laid down two principles which he believes to be fundamental. First, a state should undertake no business which can be managed and conducted equally well for all parties concerned by private ownership. Second, the federal government should undertake no business which can be managed and conducted equally well for all parties concerned by a state government. He cited the question of water powers as coming under the second head and believes the states should be allowed to control the water powers within their borders, but the state must insure proper regulation.

In answer to the objection that the older states have often allowed their resources to get away from them without proper compensation, it was stated that nearly all of the states now have commissions to look after their interests. It is also claimed that these commissions, being in closer contact with the local conditions, would be in a better position to pass on the adequacy of the returns than would be a federal board to which the same question might be referred.

Passing from states' rights to conservation, there seems to be the same unanimity on the part of the governors from the Rocky Mountain district. The prevailing sentiment may again be expressed from Governor Spry's address. After reciting some of the provisions of the earlier government land laws and the development of the newer states under those laws he makes the following statement:

> Remote from the thickly populated centers these Western states waged a vigorous campaign of land and resource exploitation in an effort to put their capital on an earning basis. Altogether, the so-called desert and waste places of the North American Continent gave abundant evidence of being among Nature's most favored localities, and spots where she had with lavish hand provided the valuable resources, which when converted to useful purposes build up communities, states and nations.
>
> A halt was suddenly called to this growth and development. Uncertainty took the place of confidence and a condition of paralysis overtook the West. Covetous eyes looked upon the heritage of the public land states.

Referring to the first Conservation Congress, called by President Roosevelt, he says: "The conference developed into a spectacular, wordy exploitation of alleged facts regarding the exhaustion of the natural resources. The moderate expressions of fear that wanton waste would work a hardship on future generations were relegated by a self appointed coterie of resource guardians. Statistics were presented, and at the time undisputed, to prove that in a short time the vast mountain ranges would be stripped of ore, that the iron age would be a thing of the past, that people would actually suffer from cold from the lack of coal, that the great American republic would soon face veritable bankruptcy of public resources."

In the discussion of the depletion of natural resources, Governor Ammons stated that there was enough coal in his state to supply this country for the next three hundred years and that Wyoming had a much larger supply. He asserted that there is a greater growth of timber in this country at the present time than is required for the present use, and that timber is being supplanted by other and better building materials.

He stated that only 4½ per cent. of the water powers of Colorado has been developed up to this time and they have not been able to market that on account of the retardation of development.

The general sentiment in respect to the various resources seemed to be the one which is so often expressed in regard to water powers, i.e., the only way to conserve them is to use them. These governors believe that the settlement of their lands, the development of their water powers, and the use of their forests under proper regulations is the correct policy to follow at the present time. They believe that the so-called conservation policy now followed by the federal bureaus is, in fact, rather a policy of stagnation so far as the West is concerned.

The proposed leasing system is not acceptable to the people of the West as it allows the title to be vested in the government and is therefore not subject to taxation no matter how valuable it may be. The only acceptable leasing system would be one in which all of the revenue accruing shall be turned over to the state. This they consider their just deserts.

A friendly challenge was laid down for any of the governors present to show wherein the position taken by the Western governors was in error. No governor present seemed to be inclined to enter the controversy on the floor of the conference.

The position of the Western group is perhaps best summed up by the following quotation from Governor Spry:

> The natural resources within the given boundaries of a state constitute the capital upon which that particular state must conduct its business and that capital should not be impaired by stagnation. The business of the government and the business of the state is being properly conducted only when the public lands go to bona fide homeseekers, when the minerals are being converted into wealth, when the waters are being used for navigation, irrigation, and power, and when the timber is being cut to build homes, school houses and public buildings.

⁂

Important Rate Decisions

The recently published report of the Public Service Commission of Missouri contains the proceedings of two electric rate cases, in both of which a substantial reduction in charges to the consumer was ordered.

SPRINGFIELD GAS & ELECTRIC CO.

In the case of the Springfield Gas & Electric Co. a maximum rate of 15 cents per kw.-hr. was being charged. Under the revised schedule ordered by the commission, the rates are as follows: Residence lighting, 8 cents per kw.hr. for the first 30 hr. and 5 cents per kw.-hr. for the remainder, with a minimum bill of 75 cents per month; general lighting, 8 cents per kw -hr. for the first 30 hr., 5 cents for the next 60 hr., and 3½ cents for the remainder, with a minimum bill of 5 cents per month for each 60-watt equivalent of connected load, there being no charge less than $1 per month, general power, 8 cents per kw.-hr. for the first 30 hr., 5 cents for the next 60 hr., and 3½ cents for the remainder, with a minimum bill of 75 cents per month for each kilowatt of connected load; large light and power service, 7 cents per kw.-hr. for the first 30 hr., 4 cents for the next 30 hr., 3 cents for the next 60 hr., and 2 cents for the remainder, with a minimum bill of $1 for each kilowatt of maximum demand; street lighting, $60 per annum per 7.5-amp. lamp and $6 per annum per 40-watt lamp. Provision is also made for a 10 per cent. discount on residence lighting, general lighting and power, and 5 per cent. on large light and power service, if the bills are paid within 10 days.

In arriving at this schedule the commission carefully investigated the values of the properties involved, the operating expenses, overhead charges and revenue. It refused to allow a separate and distinct item for "going value" or "good will," but did take into consideration, in fixing the present fair value of the property, that the plant was in successful operation as a going concern. It refused to allow a franchise value as an item in rate making, but conceded such a value in case of sale or condemnation. An attempt was also made by the company to capitalize the going value of an efficient office force; this was denied by the commission.

It appears that the defendant company, in an endeavor to boost its capitalization after the proceedings had begun, attempted through a tripartite agreement to transfer to itself ownership of the steam plant belonging to the Springfield Traction Co., from which it had purchased electricity at 1.2 cents per kw.-hr. This the commission would not allow and finally fixed the value of the defendant's property at $300,000, as against a claimed valuation of over $800,000.

After allowing a reasonable amount for overhead charges and operating expenses the commission fixed 7 per cent. as a fair rate of return on the investment and fixed the rates accordingly.

KIRKSVILLE LIGHT, POWER & ICE CO.

The second case was that of the Kirksville Light, Power & Ice Co., a small central station of only 300-kw. capacity, which had been charging at a sliding scale from 15 to 6 cents per kw.-hr. After thorough investigation the commission ordered approximately a 25 per cent. reduction in rates and prescribed the following schedule: 10 cents per kw.-hr. for the first 30 hr. of use per month, 7 cents for the next 30 hr., and 4 cents for the remainder. A minimum charge of 75 cents per month for residences is provided, and 5 cents for each 60-watt equivalent of connected load for commercial service.

As in the other case, 7 per cent. was allowed as a fair rate of return after providing for reasonable operating expenses, depreciation and contingencies. Commenting on low rates, the commission said: "Low rates for long-hour or day-time electricity from a lighting plant can be justified only on the basis that the rates charged reduce the cost to all consumers and that there is no discrimination among consumers or classes of consumers."

* * *

"Balanced Draft" Patents Upheld

A patent decision of interest to steam-boiler plant owners and operators was recently handed down by Justice Hough, of the United States District Court for the Southern District of New York. By this decision are sustained the basic patents issued to Embury McLean, covering the combination of apparatus and the method of operating a furnace which has come to be known as the "Balanced Draft" system.

These patents are owned by the Engineer Co., which will thus be given the exclusive right to install "Balanced Draft."

ENGINEERING AFFAIRS

American Institute of Steam Boiler Inspectors—At the regular meeting to be held at 29 West Thirty-Ninth St., New York City on Nov. 27, at 8 o'clock p.m., Charles S. Blake, secretary of the Hartford Steam Boiler Inspection & Insurance Co., will lecture on boilers and boiler explosions, with stereopticon views. Mr. Blake has gone through the mill as an inspector and is thoroughly qualified to give some instructive information.

Naval Architects and Marine Engineers' Meeting—The twenty-second general meeting of the society of Naval Architects and Marine Engineers will be held in the Engineering Societies Building, 29 West Thirty-Ninth St., New York, Thursday and Friday, Dec. 10 and 11.

Following is a list of the papers to be presented: "International Conference on Safety at Sea," by Hon. E. T. Chamberlain; "Safety of Life at Sea. Application of Subdivision Rules Adopted at International Conference," James Donald; "Safety of Life from Fire at Sea," W. O. Teague; "Launching Data for a Battleship," Naval Constructor J. G. Tawresey, U. S. N.; "Stability of Vessels as Affected by Damage Due to Collision," William Gatewood; "Expansion or Contraction of Certain Dimensions and the Effect upon Resistance," Prof. H. C. Sadler; "Some Experiments with Models Having Radical Variations of After Sections," Naval Constructor D. W. Taylor, U. S. N.; "Recent Developments in Submarine Signaling," J. B. Millet; "The Thermodynamics of the Marine Oil Engine;" John F. Wentworth; "Refueling of Warships at Sea," Spencer Miller; "Our First Frigates. Some Unpublished Facts About Their Construction," Hon. F. D. Roosevelt, Assistant Secretary of the Navy; "The Behavior of Riveted Joints under Stresses," James E. Howard; "The Present Status of Marine Diesel Engine Installations," W. R. Haynie; "The Application of Electric Propulsion to Battleships, together with the Experience Gained in the 'Jupiter,'" Lieut. S. M. Robinson, U. S. N.

Associated Engineering Societies of St. Louis—Ernest J. Wiederholdt, president of the Wiederholdt Construction Co., chimney builders, presented an illustrated paper on "Various Types of Chimneys" before the Associated Engineering Societies of St. Louis on Wednesday evening, Nov. 4. Mr. Wiederholdt discussed and illustrated types of guyed and self-supporting steel, common- and radial-brick, concrete, tile-concrete, and brick-concrete chimneys, discussing the points of advantage of each type. He also illustrated the advantage of protecting chimneys from lightning by throwing on the screen photographs of unprotected chimneys that had been damaged.

Joint Conference on Aviation—The Aëronautical Society of America, in collaboration with many national engineering organizations in this country, on Feb. 5 and 6, 1915, will consider inventions tending to increase the stability and safety of flight in heavier-than-air machines. The Board will do this with a view of preparing for the meeting of the joint conference such data as may enable forming a clear and correct judgment of the value of the invention, and will collaborate to this end with the inventor to the best of its abilities. The inventors, after the conference, may be given a certificate showing that their invention has been submitted to the joint conference; if the conference so decides, the opinion passed on the invention may be included in the certificate.

PERSONALS

Robert F. Carr, president of the Dearborn Chemical Co., at the recent Illinois state election was elected a trustee of the University of Illinois, from which he was graduated in Chemistry in 1893. Mr. Carr's plurality over his opponent was about 30,000. The university's board of trustees is composed of nine elective members, three to be elected every two years for a term of six years. The other members are the governor of the state, the state superintendent of public instruction and the president of the state board of agriculture.

* * *

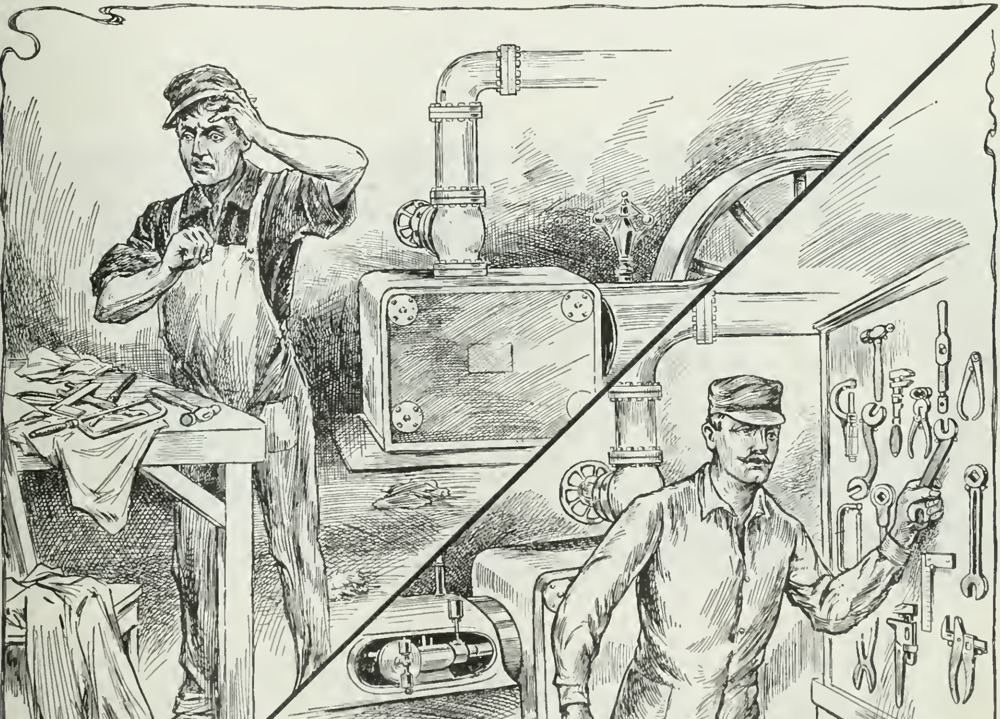
What is Fuel Oil?—Fuel oil is frequently referred to as crude oil and possibly this is the reason for the erroneous idea of its danger, for crude oil is called a fuel oil only when its flashing point is nigh and it is comparatively free from gasoline and naphtha. Crude oil itself is a mixture of a number of hydrocarbons which may be separated through the agency of heat and the first distillate gases given off in refining are very explosive so that such an oil cannot be safely used as a fuel oil.

Gasoline is driven off at a temperature of from 140 to 160 deg. F., during the distillation of crude oil, and at a temperature of 200 deg. the lighter benzines or naphthas have been separated from the crude. The residue, should distillation be stopped at this point, would be an oil that could be handled as safely as coal, but the specifications for fuel oil generally call for a fire test of 250 to 300 deg. F. Such oil contains little naphtha and cannot ignite accidentally if ordinary precautions are taken. A shovelful of red-hot ashes can be thrown into a tank of this oil without danger, or a red-hot poker may be used to stir it without fear of an explosion or ignition.

Following in the order in which the various oils are distilled from crude comes kerosene, which constitutes about one-half the mixture. This is also a good oil for fuel, but is naturally considerably more expensive than fuel oil and cannot be, therefore, considered as a practical substitute for coal for any but very small engines.

POWER

Vol. 40 NEW YORK, DECEMBER 1, 1914 No. 22



When moments are precious a well-kept tool-board is a treasure indeed

Performance of Low-Pressure Turbine Plant

By Charles H. Bromley

SYNOPSIS—Describes the equipment and gives interesting cost and performance data of a Corliss-engine-low-pressure-turbine plant, using an atmospheric cooling tower, and furnishing power for the Jenckes Spinning Co.'s plant, Pawtucket, R. I.

*

New England is a mighty busy section, and naturally economy is paramount. For generations engineers there have been brought up to a thorough realization of the importance of economical power-plant operation. The Jenckes Spinning Co.'s plant, Pawtucket, R. I., reflects the alertness of New England operating engineers and is a criterion by which to judge the best-conducted plants in that section. The plant operates day and night.

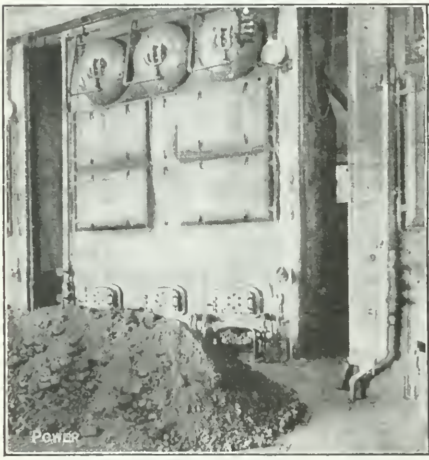


Fig. 1. Coal for the Test

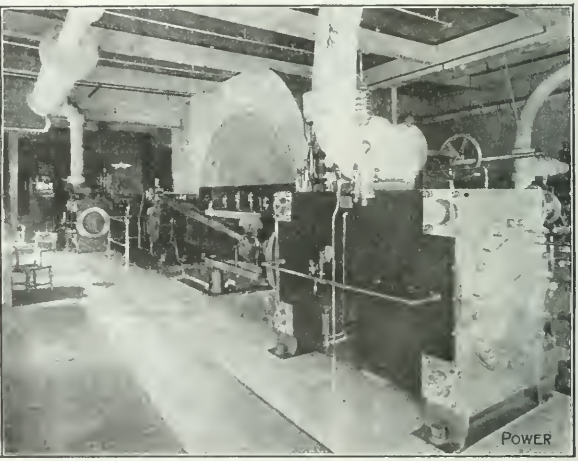


Fig. 2. The Two Simple Corliss Engines

Before the recent alterations and additions, this plant was furnished power by three Corliss engines running noncondensing. The company's chief output is tire fabrics and to keep pace with the automobile industry it became necessary to increase its power capacity.

Of the three engines of 850, 400 and 500 hp., the two former were retained, but the other having served its useful life, was discarded when the advisability of installing a low-pressure turbine became imminent. As its chief equipment the plant has now two 500-hp., one 250-hp. and one 400-hp. water-tube boilers; the simple Corliss engines mentioned; one 1000-kw., 60-cycle, three-phase, low-pressure turbo-generator excited by a 35-hp. induction-motor-driven generator; one auxiliary turbine-driven exciter; one 395-hp. synchronous motor; one surface condenser and one atmospheric cooling tower 20 ft. wide, 90 ft. long by 30 ft. high, which with the Rotrex air pump (the latter removes air and condensate in one cylinder) was guaranteed to condense 35,500 lb. of steam per hour and produce a vacuum of 3 lb. absolute pressure with an air temperature of 70 deg. and relative humidity of 70 per cent.; the guarantee was more than fulfilled. The feed pump is of the direct-acting duplex type exhausting into a closed heater fed by bleeding steam in from the pump and other auxiliaries.

The condensate, as usual, goes to the hotwell, the necessary makeup water being taken from the city mains, the total being measured on the way to the boilers by a 4-in. venturi meter.

The Boilers

The 520-hp. and the 250-hp. boilers are used for power purposes while the 400-hp. is for heating; all are hand-fired and furnished with natural draft. The coal is Crozer-Pocahontas, from the Crozer properties in McDowell County, W. Va. From this district, the coal runs about 2.72 per cent. moisture, 13 to 15.4 per cent. volatile, 77 to 86 per cent. fixed carbon, 4.4 to 5 per cent. ash and 0.55 to 0.77 per cent. sulphur. The heat value on the "as received" basis will average about 14,500 B.t.u.; when analyzed on the "moisture and ash free" basis, it runs up to as high as 15,860 B.t.u.

After the low-pressure turbine was installed it was desired to test the plant for efficiency under the usual day and night loads, the efficiency of the boiler plants, and the cost per horsepower-hour as determined by test over a seventy-two-hour period. The Massachusetts Institute of Technology was therefore called on and conducted the test, many of the data from which is given herewith.

A summary of the results obtained for the day, night and seventy-two-hour tests follows:

BOILERS

Boiler No.	Use	Hp.	Type	Heating Surface, Sq.ft.	Grate Surface, Sq.ft.
1	Power	520	B & W horizontal water tube	5085.5	90
2	Power	520	B & W horizontal water tube	5085.5	90
3	Power	250	B & W horizontal water tube	3900.5	60
4	Heating	400	B & W horizontal water tube	......	90

RESULT OF TESTS

Boiler Plant

Heat of combustion of coal as fired: 14,680 B.t.u. per lb.	
Total equivalent evaporation from and at 212 deg. F.	
Day	28,200 lb.
Night	19,910 lb.
72 hours	24,300 lb.
Equivalent evaporation from and at 212 deg. F. per pound of dry coal:	
Day	11.44 lb.
Night	10.54 lb.
Test	11.10 lb.
Equivalent evaporation from and at 212 deg. F. per pound of combustible:	
Day	12.33 lb.
Night	11.34 lb.
Test	11.91 lb.
Equivalent evaporation from and at 212 deg. F. per sq.ft. of heating surface per hour:	
Day	2.02 lb.
Night	1.42 lb.
Test	1.66 lb.
Coal burned per sq.ft. of grate surface per hour:	
Day	10.34 lb.
Night	7.95 lb.
Test	9.25 lb.
Boiler horsepower developed, A. S. M. E. rating:	
Day	813.1
Night	576.9
Test	703.0
Maximum assumed possible error of test, per cent	1.88
Air per pound of coal from analysis of flue gas	28.2 lb.
Air required per pound of coal from the formula $(12\,C + 36\,[H - O/8])$	10.78 lb.
Excess air supplied, per cent	161.5
Heat carried off by flue gases per pound of coal	2,506 B.t.u.
Heat taken up by water in boiler per pound of coal	10,650 B.t.u.
Total heat furnished per pound dry coal	14,720 B.t.u.
Heat radiated per pound dry coal	1,564 B.t.u.
Heat carried off by flue gases, per cent	17.1
Heat loss by radiation, per cent	10.63
Thermal efficiency of boiler plant, per cent.:	
Day	75.4
Night	69.5
Test	72.8
Cost of 1000 lb. of steam	18.2
Cost per hp.-hr., cent	0.494
Cost per kw.-hr., cent	0.662

Entire Plant

Hp. output:	
Day	2,008.6
Night	867.7
Test	1,578.7
Pounds coal fired per hp. per hour:	
Day	1.23
Night	2.21
Test	1.41
Pounds steam per lb. coal as fired:	
Day	10.92
Night	10.19
Test	10.64
Pounds steam per hp. per hr.:	
Day	13.50
Night	22.4
Test	14.97
Thermal efficiency, per cent.:	
Day	14.15
Night	7.94
Test	12.4

An average of 23,600 lb. of water per hour was used in the power boilers, 27,135 lb. per hour during the day and 19,435 lb. per hour for the night. The heating boiler used an average of 5920 lb. per hour for the entire test, while an average of 5280 lb. per hour of makeup water was added to the total feed supplied. The equivalent evaporation per square foot of heating surface per hour for the seventy-two hours was 1.66, and the coal consumption per square foot of grate was 9.25 lb. This gave an equivalent evaporation from and at 212 deg. F. of 11.91 lb. of water per pound of combustible. The data covering the flue gases are made up of the totals of CO, CO_2 and O readings taken during the five shifts over which the tests extended.

FLUE GAS

	CO	CO_2	O
	0.20	17.80	21.2
	0.50	27.55	88.8
	3.40	55.40	77.8
	0.20	30.40	90.8
	1.20	63.60	114.1
Total	5.50	194.75	392.7
Average	0.183	6.491	13.09

CO	0.18
CO_2	6.49
O	13.09
Total	19.76
N, per cent	80.24

Temperature flue gas = 427 deg. F.

	Per Cent.
Moisture	1.0
Ash	6.9
Hydrogen	2.8
Oxygen	4.2
Carbon	83.0
Sulphur	0.8
Nitrogen	1.3
	100.00

COST OF OPERATION PER HOUR (110 HOURS PER WEEK)

Repairs at $335 per month	$0.761 per hour
Oil and waste at $175 per month	0.398 per hour
Labor (day) at $130 per week	1.180 per hour
Labor (night) at $75 per week	0.681 per hour
Coal, weight burned per hour, 2219 lb., at $4.40 per ton	4.780 per hour
Total	$7.800 per hour

Cost per horsepower-hour

$$\frac{780.00}{1579} = 0.494 \text{ cent}$$

Cost per kilowatt-hour

$$\frac{780.00 \times 1000}{1579 \times 746} = 0.662 \text{ cent}$$

A heat balance for the seventy-two hours showed that of the available heat, 72.8 per cent. went for making steam, 17 per cent. was carried away by the flue gases and 10 per cent. was radiated away. The coal consumption per horsepower-hour as fired was 1.23 lb. for the day, 2.21 lb. for night, and 1.41 lb. over the seventy-two hours.

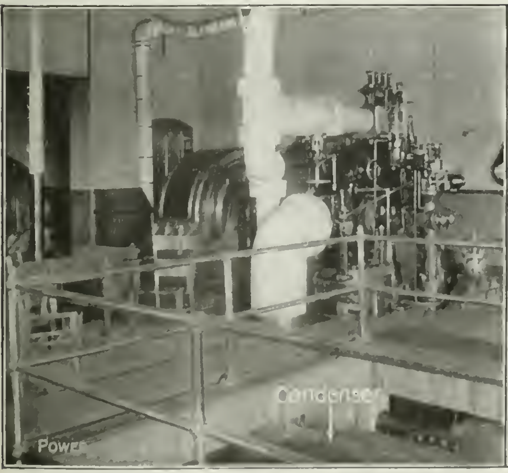


Fig. 3. The 1000-Kw. Low-Pressure Turbine

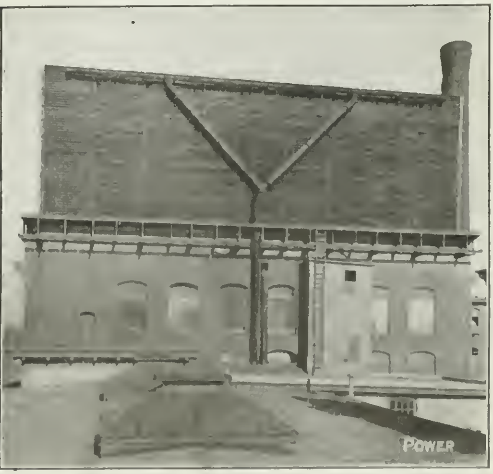


Fig. 4. Atmospheric Cooling Tower on the Roof

The quantity of steam per horsepower-hour was 13.5 lb. during the day, 22.4 lb. for the night, making it 14.97 lb. for the entire test period. The night results all through the test were comparatively poor, chiefly because at this time the engine and the turbine were running under half load.

The vacuum at the turbine was maintained very high, a trifle above 29 in. The barometer registered an average of 30.02 in. for the entire period, or an equivalent of 14.78 lb. atmospheric pressure.

Distribution of Purchased Power Charge

Tests made prior to the installation of the low-pressure turbine showed that for the 104-hr. week an average of 1021 hp. was being developed. This gives 106,184 hp.-hr. per week. The corresponding coal consumption was 355,990 lb., giving 3.345 lb. coal per horsepower-hour. These were the results obtained under noncondensing reciprocating-engine conditions. Before the low-pressure turbine was used, about 300 hp. was purchased from the city at \$35 per horsepower, the purchased power costing at this rate \$10,500 per annum.

PRINCIPAL EQUIPMENT OF JENCKE'S SPINNING CO.'S PLANT, PAWTUCKET, R. I.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Water tube	520 hp	Power		Babcock & Wilcox Co.
1	Boiler	Water tube	250 hp	Power		Babcock & Wilcox Co.
1	Boiler	Water tube	400 hp	Heating		Babcock & Wilcox Co.
1	Engine	Simple Corliss	850 hp. 30x60 in.	Power	Belted; exhausts to low-pressure turbine	Harris Steam Engine Co.
1	Engine	Simple Corliss	400 hp 24x48 in.	Power	Belted; exhausts to low-pressure turbine	Harris Steam Engine Co.
1	Turbine	Low-pressure	1000 kw	Generator drive—direct	R.p.m. surface condenser	General Electric Co.
1	Generator	Alternating current	1000 kw., 3 phase.	Power and light	60 cycle, turbine driven	General Electric Co.
1	Motor	Synchronous	395 hp., 600 volts	Power	Belted to line shaft	General Electric Co.
1	Condenser	Surface	4800 sq.ft. tubes	Vacuum for turbine	With cooling tower; 29.3 in. vacuum in winter	C. H. Wheeler Mfg. Co.
1	Cooling tower	Atmospheric	90x20x30 ft.	Cooling condenser circulating water		C. H. Wheeler Mfg. Co.
1	Air pump	Wet type (Rotrex)		Surace condenser		C. H. Wheeler Mfg. Co.
1	Pump	Centrifugal		Circulating water, condenser	driven	C. H. Wheeler Mfg. Co.
1	Pump	Duplex plunger		Feedwater	Water from hot well	Henry R. Worthington
1	Heater	Closed		Feedwater		Henry R. Worthington

NOTE: The coal is furnished by S. P. Burton & Co., Boston, Mass.

The data given above for the seventy-two-hour test made after the turbine was installed show that 1578 hp. was averaged, and that the coal consumption was 1.41 lb. per horsepower-hour, giving a difference in fuel consumption between noncondensing-reciprocating engine and low-pressure turbine conditions of 3.345 — 1.41 = 1.935 lb. per horsepower-hour. If this last amount is multiplied by 1578, which represents the load in horsepower for a week, we get 3053.33 lb. or 1.375 long tons per hour. For the usual 104-hr. week the fuel saving on this basis amounts to 104 × 1.375 = 143 long tons. If the plant runs fifty weeks per year (allowing for holidays) the yearly saving is 143 × 50 = 7150 tons. As the price paid for the coal is \$4.40 per ton, the yearly saving on this basis is \$31,460.

But under the new conditions no exhaust steam is available for heating as there was when the plant was operating noncondensing. From the report we learn that for the seventy-two-hour test, conducted Apr. 1, 2 and 3, when the average outside temperature was 43.9 deg. F., there was an average of 47,736 lb. of coal burned in the heating boiler. After making due allowances for the factors influencing the consumption of coal for heating, one concludes that \$10,000 per year is a liberally fair per annum charge. Prior to using the turbine the cost of purchased power (300 hp.) was \$10,500 a year, and this charge, which ceased when the turbine went into service, goes a long way toward balancing the \$10,000 required for heating now that the turbine uses the exhaust steam.

There is no true balance between these items, however, for the reason that when the power was purchased it cost \$10,500 a year, which on the basis of a 104-hr. week, 50 weeks per year, gives 1,560,000 hp.-hr. or $\frac{10,500.00}{1,560,000} =$ 0.672c. per hp-hr.

At present, power is produced for 0.494c. per horsepower-hour, giving a difference of 0.672 — 0.494 = 0.178c., which, on 1,560,000 hp.-hr., totals \$2776.08. As this 300 hp. is still being used it would not be correct to charge off the entire amount of \$10,500. The amount to charge off is the difference between what this 300 hp. formerly cost and what it now costs. This difference is \$2776, and is all that should be charged off in the plant's favor. If one were hypercritical, he could justly further reduce this amount by deducting sufficient to cover the interest, insurance and depreciation on 300 hp. of the 1000-kw. turbine. It is apparent then that instead of there being a saving of \$10,500 to offset the \$10,000 now needed for heating, there is only \$2776, giving \$10,000 — 2776 = \$7224 to be deducted from the amount saved on the total power produced. Figured from the coal pile, this saving is \$31,460, which minus the \$7224 gives \$24,236, exclusive of overhead charges, as gain on a yearly output of 1,560,000 hp.-hr.

Allowing \$20 as the cost per kilowatt of the turbine installed and \$7 per kilowatt for the condenser, cooling tower and pumps, the cost of the turbine installation becomes \$27,000. If 12 per cent. is allowed for overhead charges, the net yearly saving is \$21,000.

⁂

Use of Close Nipples—It is a difficult matter to make tight joints where close nipples are in sizes as large as 8 in., as there is not enough space for the use of a Stillson wrench. If the threads on the nipples are not perfect, considerable trouble will be experienced. They are also difficult to repair. Nipples for the larger sizes of pipe should be at least 8 in. in length.

⁂

Slippage of Reciprocating Pumps—It is folly to assume a general figure of 5 per cent. as the slippage of reciprocating pumps. As shown by test results the slip may be anything from 5 to 85 per cent., depending on the condition of the pump, the discharge pressure and piston speed.

If a pump is not kept in good order the slip may increase rapidly, even if the running conditions are kept constant. The following data are available concerning slippage tests on a 40-million-gal. pump:

	Slip, per cent.
June 10	1.7
June 26	5.2
Aug. 8	7.8
Aug. 15	12.4
Sept. 15	20.0
Sept. 18	22.9
Oct. 14	28.5

From such tests engineers are beginning to understand that they cannot assume the slip of their pump to be, say, 5 per cent. They are beginning to realize that there is a wide range of values of slip, and that for the economical operation of their plant they must determine how they can reduce slippage to a minimum.

First Large American-Built Humphrey Pump

By Charles C. Trump

SYNOPSIS—Details of construction of a 66-in. Humphrey pump for Del Rio, Texas. This pump is much simpler than the English design and the working parts have been standardized.

* * *

The first Humphrey pump to be installed in the United States of a size comparable with those in operation at Chingford, England, will be used for irrigation work on the G. Bedell Moore estate near Del Rio, Texas. In design it differs from the English type in several important details, the requirements of American pumping-engine practice, as well as experience with the Humphrey pump abroad, having made it advisable to simplify the construction. Furthermore, the opportunity for standardizing the working parts to fit a line of different-sized pumps has been seized and, wherever possible, as in the case of the water valves, that type of construction has been adopted which has stood the test in years of service.

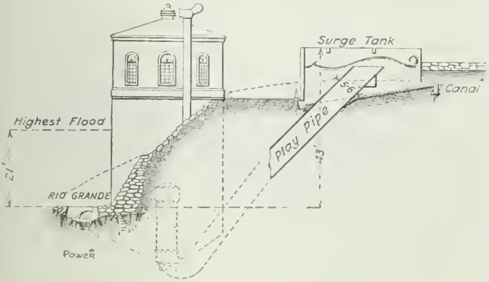


Fig. 1. Elevation of Installation

As seen in Fig. 1, this pump has the shape of a short-legged V, the playpipe extending up the bank of the Rio Grande at an angle of 45 deg. with the horizontal from a two-part bend of 135 deg., upon which the water valves, and above them the vertical power cylinder, are set. The upper end of the playpipe is embedded in a concrete surge tank while the lower end, including the bends, is firmly held in reinforced concrete, which forms the bottom of the pump well; the walls are carried high enough to keep out the flood waters. Two gate valves control the flow from the river into this well, one to be operated and set by hand, the other to be regulated hydraulically by a float gear to maintain the proper level over the intake valves of the pump. On an operating floor, just above the intake water level, are the auxiliaries for starting, ignition, etc., while all the gas and exhaust piping is arranged vertically in the well, leaving space around the cylinder for convenience of operation.

A gas holder of 500 cu.ft. capacity has been provided to take care of the intermittent demands. Instead of a water-sealed gas receiver near the pump, a longer vertical tank of smaller diameter will stand against the wall of the well nearest the gas holder and will be connected to the latter above by short pipes, and below, through a check and throttle valve, with the gas belt of the pump. This receiver will be strong enough to withstand any explosions that may occur by reason of air in the gas line on starting; these, in any event, would probably blow the water seal of the gas holder. The short connection between the receiver and the pump will make it possible for the latter to draw a full charge on each stroke without appreciable reduction in pressure.

A 300-hp. Akerlund down-draft producer will furnish gas for the pump and be capable of gasifying either soft coal or mesquite wood. The latter is obtainable by the necessary clearing of the land to be irrigated and will be used alone or in combination with semi-bituminous coal until the supply is exhausted, after which soft coal will be used entirely.

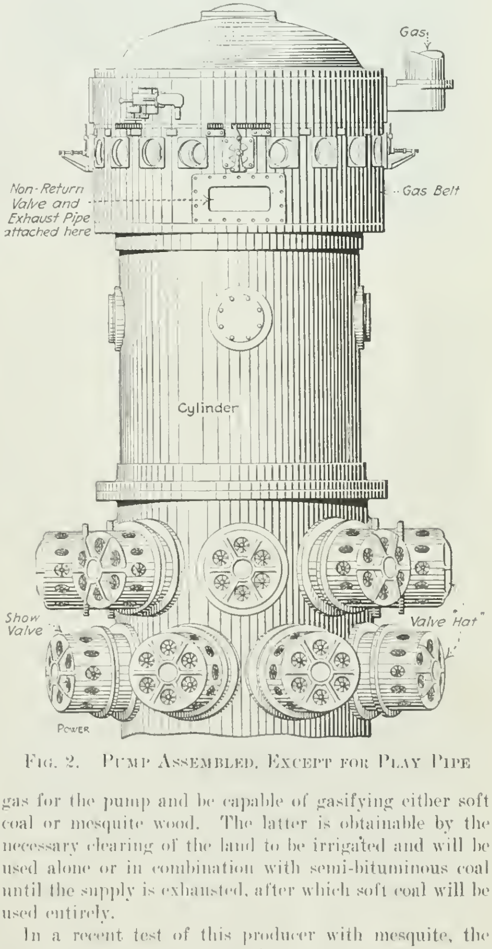


Fig. 2. Pump Assembled, Except for Play Pipe

In a recent test of this producer with mesquite, the following results were obtained:

Gas generated per pound of wood	54.7 cu.ft.
Heat value of gas per cubic foot	114.5 B.t.u.
Wood per square foot of fire area	20.8 lb.
Wood per horsepower-hour	1.76 lb.

The cleaning apparatus will consist of only the usual two tower scrubbers—a coke scrubber and a dry scrubber. The gas will be supplied under pressure to the pump by means of a pressure blower. Water for cooling, scrubbing and sealing the ashpits, as well as that vaporized in the producer, will be furnished by a triplex plunger pump. The power required to drive the producer plant auxiliaries will amount to 8 or 10 hp., and this, together with that required for the pump auxiliaries, will be furnished by one of two gas engines of 15 hp., either of which will be sufficient for starting the plant and operating the necessary auxiliaries continuously.

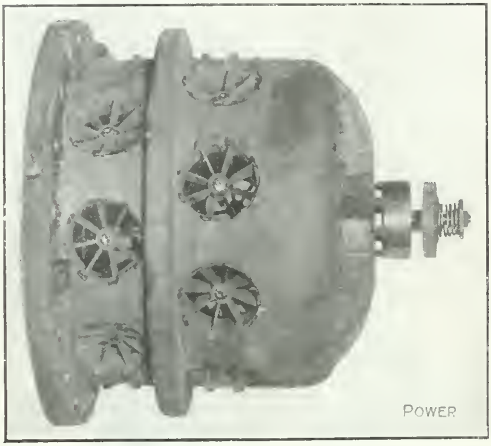


FIG. 3. WATER-VALVE CAGE

The auxiliaries for the pump proper consist of a two-cylinder compressor for starting by air and gas, a pump for draining the well, and possibly a crane hoist for handling water-valve cages, etc.

Ignition apparatus and electric lights will be supplied by a direct-current generator driven by one of the gas engines. A duplicate set of storage batteries with interrupters to operate the jump-spark ignition has been provided with an arrangement for charging from the power and lighting circuit.

PUMP DETAILS

On top of the bend is set the box for the water-intake valves with its "hat" unit construction, as shown in Fig. 2. The box itself is a steel casting, weighing in the neighborhood of 3000 lb., and having openings for 16 hats or cages (see Fig. 3) containing 25 valves each, or a total of 400. The valve cages are semi-steel castings, into which the valve seats of manganese bronze are forced with a taper fit. The water valves are of the standard Underwriters' type and of 5 in. diameter, the rather large size being permissible in view of the slower speed and more gradual closing in the Humphrey, as compared with other pumps. Because of considerable sand in the river water, the valve disks will be made of a composition instead of rubber.

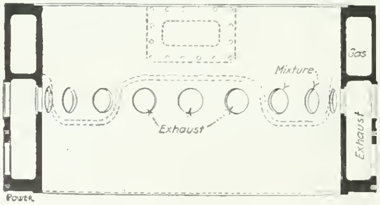


FIG. 4. MIXTURE AND EXHAUST BELTS

The cylinder above the water-valve box forms part of the combustion chamber, and is of riveted steel-plate pipe 66 in. inside diameter and 89 in. long. The plate is $\frac{15}{16}$ in. thick, with triple-riveted butt-strap joints inside and out.

The belt for gas valves shown in Fig. 2 contains the important working parts of the pumping engine. The belt itself is a steel casting weighing about 7500 lb., and is in the form of a double-walled section through which there are openings for the inlet and exhaust valves. In all, there are 20 of these openings, all at one level; 12 are for exhaust valves and eight for inlet valves. In order to have an even distribution of flow of the gases into and out of the cylinder, these openings are arranged in groups of two for mixture and three for exhaust separated by a dividing rib (see Fig. 4), which runs over the exhaust valves and under the mixture valves, around the annular space between the outer and inner walls of the belt itself. Thus the belt is divided into an upper chamber, having a rectangular opening to which the gas pipe is connected, and a lower chamber with two larger openings for attaching the two nonreturn valves and the exhaust pipes. The reason for leading the exhaust gases downward is to allow any water carried with them to drain off.

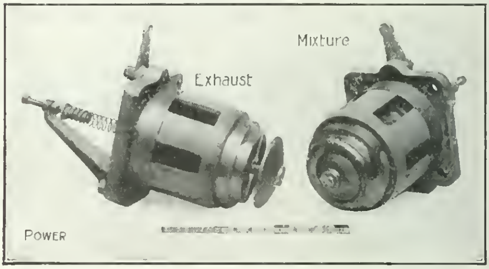


FIG. 5. INLET- AND EXHAUST-VALVE UNITS

Each mixture-valve cage is assembled as a unit and, as shown in Figs. 5 to 7, contains a double, flat-faced bronze valve of the mushroom type with a tubular stem. The outer end of the valve stem is threaded inside for a locking nut or head, which is fastened by an expanding bolt acting inside the quarter-threaded projection. The seat on which the valve works is also double faced, there being two concentric openings of equivalent area; the inner one is for air drawn directly through the cage cover around the valve stem and the outer one takes gas from the upper chamber of the belt. This arrangement keeps the tar or other impurities which may be carried in the gas as far as possible from the moving stem. On the cage cover is carried the locking lever hung on a pivot stud and so set as to allow the hooked end to wedge under the stem head, without the aid of a spring, and lock the valve tight. The upper end engages with a lug on the interlocking chain, which displaces the lever to unlock the valve.

The spring which closes the mixture valve is adjustable, and a throttle plate, Fig. 8, is provided for controlling the supply of air to be mixed with the gas; a setscrew holds the adjustment.

The exhaust-valve-cage unit, also shown in Figs. 5 to 7, is interchangeable with that for mixture and differs from it in only a few details. The valve is also of the mushroom type, but has only one flat face at its outer circumference. This makes it lighter, which is advantageous, since the exhaust valve is closed with some violence by the rising of water in the cylinder. The valve is opened by an outside spring and much depends upon getting it open immediately at the end of expansion to atmospheric pressure, so as to draw in a full volume of scavenging air by the subsequent suction. This air is drawn in through the exhaust-valve cage directly. A spring-closed scavenging valve (see Fig. 7), which has its seat against the inside of the exhaust-cage cover, prevents the products of combustion from escaping into the air, and the nonreturn valves outside the belt keep the exhaust gases from returning into the cylinder instead of to the fresh air. In case the products of combustion left in the belt contaminate too much the small cushion volume, separate scavenging valves may be necessary on the steel-plate cylinder.

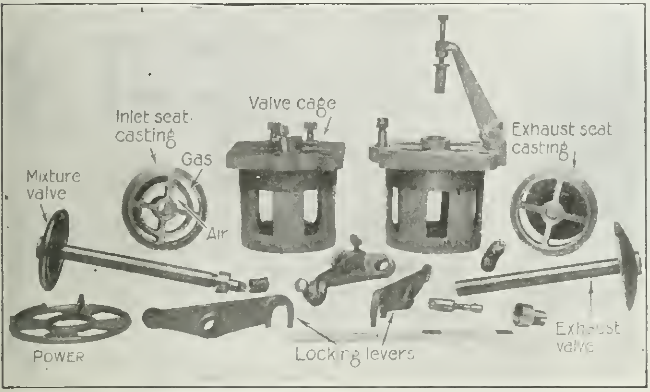


Fig. 6. Valve Units Disassembled

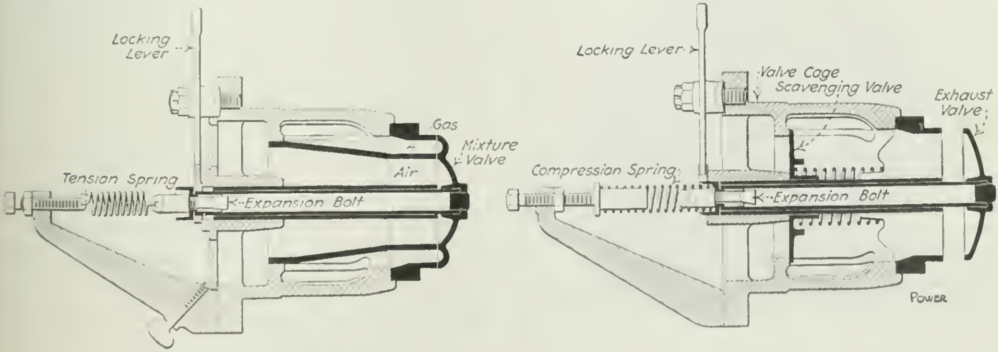


Fig. 7. Sections through Mixture- and Exhaust-Valve Units

Upon the interlocking mechanism depends the operation of the four-stroke cycle. Bearing this in mind, it is necessary to lock the mixture valves during the expansion following the power stroke, and to lock the exhaust valves and unlock the mixture valves to admit gas and air during the charging stroke, which follows the first compression of the cushion and precedes the compression of the new charge. This is accomplished by a sprocket roller chain stretched about the belt above the gas valves, and carrying lugs which engage the locking levers of the exhaust valves in one direction and the mixture-valve levers in the other. The chain is moved by a shifter operated by a small spring-loaded piston in a cylinder connected with the play pipe. Every time the pressure in the play pipe rises, as it does both with the explosion and with the "cushion," the piston pushes the chain over. The mechanism is such that the explosion causes the chain to move toward the upper ends of the exhaust-valve locking levers and unlock the exhaust valves. The cushion simply pushes the shifter the other way and unlocks the mixture valves which were allowed to lock before by the action of gravity on the locking levers. The shifter is connected to the chain through a shaft to one of the sprockets on which the chain rides. Fig. 9 shows the head of a similar but smaller pump, with the chain and shifting mechanism attached.

A better idea of the operation of this shifter may be gained by reference to Fig. 10. When the pressure in the play pipe falls, the large spring forces the shifter piston to the right, drawing the spear-headed connecting-rod back away from the upper pin on the tee lever. A small, tension, toggle spring, connecting a pin on the lever with a pin on the spear-head, is not as strong as the large spring on the piston, but it immediately tends to pull the connecting-rod into a straight line of centers. Thus when the piston has returned to its initial position, the socket of the spear-head is in a position to engage with the lower pin on the lever. The next rise of pressure, therefore, will push the lever over and thus move the chain, which interlocks the valves in the opposite direction. The sharp point on the spear-head and the small pin which is to be seen under the toggle spring near the center of the tee lever make it practically impossible for the piston to move under the influence of pressure without engaging one or the other sides of the lever. In this way the alternate locking and unlocking of the mixture and exhaust valves is accomplished, and the duration may be varied to produce the correct effect upon the combustion.

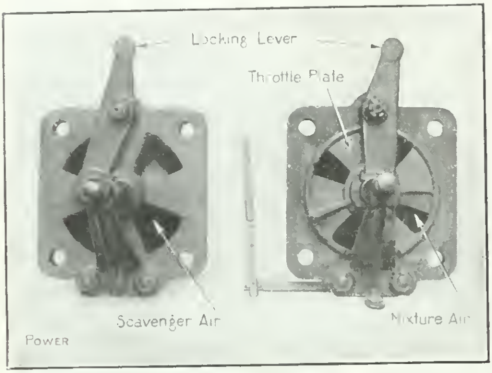


Fig. 8. Showing Throttle Plate and Locking Levers

To make the ignition system reliable under the conditions peculiar to the Humphrey pump has been no small task. The presence of water in the combustion chamber made electric ignition the only possibility, and beset that with difficulty. Both high-tension jump-spark and low-tension electromagnetic make-and-break or arc systems have been developed. Besides these two powerful systems, which are provided for each pump in duplicate, there is also a conventional set of automobile spark coils, plugs and storage batteries arranged to fire the initial charge in the cylinder by hand with a switch or push-button. All of the spark plugs for these ignition systems are placed in the cylinder head. The induction coils are fastened as near to their respective plugs as possible to reduce the danger of leakage of high-voltage discharges and are protected so far as possible from moisture.

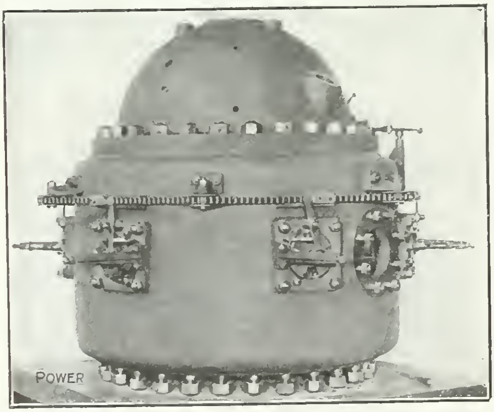


Fig. 9. Gas Head of Smaller Pump, Showing Chain in Position

In addition to the igniters the domed head is pierced with numerous holes to admit air and gas for starting. This is accomplished in a simple manner by pumping in a mixture by means of the two-cylinder compressor, pumping air and gas in proper proportions by separate pipes to a tee just outside the dome. The first cylinderful of inflammable mixture fired above the water in the play pipe will be enough to start the column and fill the play pipe with water; it may not even be necessary to pump in another charge under compression to get the pump in motion for steady operation.

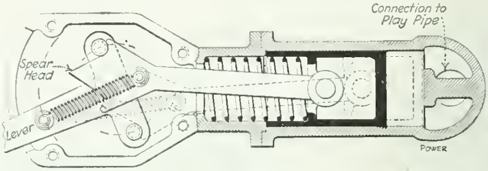


Fig. 10. Section through Shifter

The pump has been designed and built by the Humphrey Gas Pump Co., of Syracuse, N. Y. under Humphrey patents and those of W. H. Smythe, the latter having done pioneer work in this line.

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Indicated Power from Diagram of Proportional Length

By J. S. A. Johnson

In a direct-acting steam pump the stroke is not of constant length. Consequently, in determining the power with an indicator, the usual formula

$$\frac{PLAN}{33{,}000} \qquad (1)$$

does not apply unless the length of stroke L be measured at the time the diagram is taken.

A better plan is to ascertain the piston travel corresponding to one inch of length of indicator diagram, either measured or calculated from the reducing motion, and modify the usual formula.

Let

L = The length of stroke in feet;
A = Area of the piston in square inches;
N = Number of strokes per minute;
S = Scale of indicator spring;
m = Length of the diagram in inches;
$\frac{L}{m} = R$ = Piston travel, per inch of diagram length;
a = Area of the diagram in square inches.

The mean effective pressure P being equal to $\frac{aS}{m}$, then the familiar formula becomes

$$hp. = \frac{aSLAN}{m \times 33{,}000} = \frac{aSRAN}{33{,}000} \qquad (2)$$

It will be seen from formula (2) that in calculating the power it is only necessary to count the number of strokes per minute and measure the area of the diagram. This method would in fact be more convenient for calculating the power of all types of engines, as the value of the product SR in formula 2 is simply the number of foot-pounds per square inch of piston area per stroke for each square inch of the diagram.

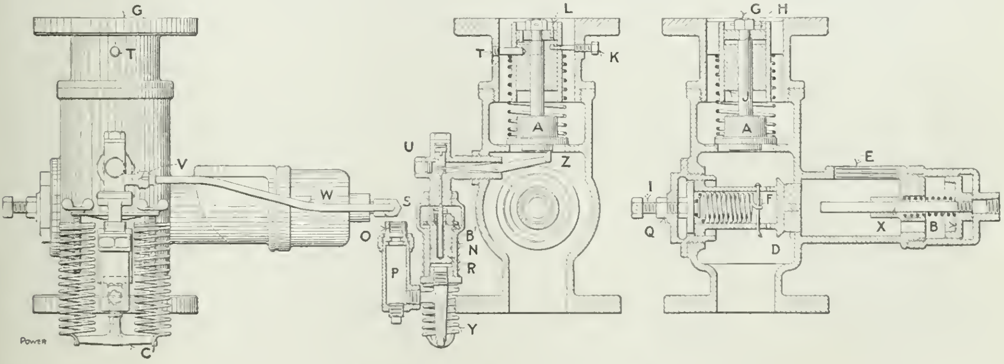
New Starting Unloader for Motor-Driven Compressors

A starting unloader for motor-driven compressors, in which the motor current is cut out or in to stop or start the compressor when a maximum or minimum load is reached, has recently been put on the market by the Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn.

The unloading action is obtained by the velocity of the air pressure passing through the chamber and by the variation of the receiver pressure.

The compressor is unloaded when the speed is reduced about twenty-five per cent.; by this action any recoil on the last revolution experienced when stopping against a load is obviated.

When the motor starts, the air is bypassed to the atmosphere until the desired speed is obtained, at which point the bypass valve closes and the air passes to the receiver until the predetermined pressure at which the current is cut out is reached. Then the bypass is opened by the receiver pressure and trigger against the unloading piston. With the compressor unloaded, the intake air has then a practically free passage through the cylinder, with a resultant cooling effect until the machine stops.



Details of the Design of the Unloader

The different loading and unloading operations are dependent upon the speed of the machine and are automatic. When the current is cut out and the compressor slows down, the bypass valve opens automatically and unloads before the compressor stops. When the current is cut in, compression does not occur until the motor has obtained the desired speed.

The advantage of this unloader is that a compressor so equipped will require less power to start. Such a compressor can therefore be driven by a motor of less power than is ordinarily used. The operating parts are few and simple, and consist of a bypass valve *D*, a check valve *A*, unloading piston *B*, and the trigger *C'*. The detailed operation, referring to the illustrations, is as follows:

The air from the compressor discharge port enters at the bottom of the unloader and passes through the open valve *D* to the atmosphere at *E* until the bypass valve *D* is closed by the velocity overcoming the tension of the spring *F*. The air then lifts the check valve and passes to the receiver, connected at *G*. The check valve *A* is controlled by the dashpots *H* and *J* to prevent its seating at every stroke; the time of seating is regulated by the vent screw *K*. The small valve *L* is a vacuum breaker to allow the check valve to lift freely. *T* is a fixed pin for holding the dashpot bushing in place.

The receiver pressure to operate the trigger mechanism enters the trigger cylinder *N* through the port *O* and filter *P*, and acts on the piston *R* to close the bleeder valve when the pressure is within 3 lb. of the maximum.

As soon as the motor current is cut out and the speed is reduced about 25 per cent., the check valve *A* seats and presses down the lever *Z*, lifts the pilot valve *U*, admitting pressure from the chamber *V* through the tube *W*, behind the piston *B*. The bypass valve *D* is forced open by the piston rod *X*.

When the receiver pressure has dropped about 3 lb., or any predetermined amount, the tension springs *Y* pull down the trigger piston *N* and the bleeder valve *S*. After starting again and the velocity has closed the bypass valve *D*, the accumulating pressure in the valve chamber blows out of the pilot valve *U* and the bleeder valve *S* until the check valve *A* lifts and the lever *Z* releases the pilot valve and allows it to close.

The tension on the springs *Y* is usually so adjusted that the pressure under the piston *N* closes the bleeder valve *S* when within 3 lb. of maximum and opens the valve when the pressure has dropped that much. To prevent any possible leakage past the pilot valve *U* from acting on the piston *B* and forcing the bypass valve *D* open, a minute hole is drilled at *V* to permit this air to escape.

Just before unloading occurs, the bleeder valve *S* closes and allows the full pressure to act on the piston *B*. While loading it is kept open to prevent the pressure from acting on the piston. The baffle washer B' is to prevent any cylinder oil which may blow out of the bleeder valve from coming in contact with the piston *R*. The unloader is generally placed on the discharge port of the compressor cylinder, but it may be put anywhere in the discharge line near the cylinder, and its efficient operation will not be hindered.

The adjustment of the unloader to the required conditions of the compressor is particularly simple. When the compressor is near the desired speed, the locknut *Q* is backed away and the thrust screw *I* is turned in, thus moving the bypass valve *D* toward its seat until it is closed automatically by the velocity of the escaping air; then the locknut is set up.

When the receiver pressure is within about 3 lb. of the maximum or cutting-out point, the springs on the trigger are so adjusted that the pressure under the piston *R* closes the bleeder valve *S*, and, conversely, opens the valve when the pressure has dropped the same amount. After these two single-spring adjustments have been made, the compressor is ready for its regular work under the required conditions of speed and pressure.

The unloader in no way controls the starting and stopping of the motor; it merely unloads the compressor and keeps it so until it is again started and up to the required speed. The control of the motor current is accomplished by some one of the standard controlling switches and circuit-breakers.

* *

Methods of Suspending Motors

By Francis H. Davies

SYNOPSIS—Practical ways of attaching electric motors to walls, ceilings or columns so as to secure both rigidity and neat appearance.

*

The placing of electric motors in out-of-the-way positions on walls, ceilings or columns often introduces problems of some little difficulty. Generally speaking, many ways of meeting such cases will occur to the practical man, but the less experienced erector, having little in the way of precedent to guide him, may find the accompanying illustrations of service.

Wall suspension introduces the least difficulty, but it is essential first of all to make sure that the wall or beam is capable of withstanding the strain, not only of the belt pull, but also of continual vibration. There are no rules governing the former point, which must, therefore, be left to experience, but the effects of vibration may be diminished to a large degree by inserting a good hair felt or rubber pad between the base of the motor and the wall. In such cases it is necessary also to bush the bolt holes in the base with a similar substance and to insert suitable isolating washers under the iron washers to prevent vibration being transmitted through the bolts. Figs. 1 and 2 show, respectively, the simplest and most usual methods of bolting to timber and brick or concrete walls. They are self-explanatory and it is necessary only to mention that the anchor plates on the outside of the wall should be of large area so as to distribute the pull as much as possible. Expansion bolts may be employed for small motors, but for those of any size the bolts should extend through the walls.

A smooth seating for the motor is very necessary, otherwise it will be likely to set up vibration and become loose as the projections upon which it rests wear down. For this reason it is always advisable to interpose a piece of felt as before mentioned, or, failing this, a sheet of lead will be satisfactory. If it is essential that the motor should operate in its normal upright position, it must be installed upon a bracket mounted on the wall, as in Figs. 3 and 4. The first of these is of wooden construction and is useful for small motors. It is composed of two brackets placed a suitable distance apart and fitted with a substantial wooden platform to which the motor is bolted. The members are held together by coach screws, but the joints should be as accurate as possible in the interests of strength. If preferred, a piece of boiler plate makes an excellent substitute for the wooden platform. The bracket shown in Fig. 4 is constructed of angle iron and is suitable for any size of motor that would be installed in such a position. It is best to rivet the shelf to the angle-iron supports, using rivets with countersunk heads to allow a smooth surface. If the motor is comparatively light it is possible to dispense with the bottom struts, stout angle steel being used to support the bracket. In this case, however, it is better to substitute two triangular or gusset-shaped pieces of plate, riveting a piece of angle iron to the upper edge to allow the platform to be bolted down and another to the edge that bears on the wall to carry the fixing bolts. Practically every wall fixing problem may be met by one or other of these means with slight modifications.

The fixing of motors to ceilings or horizontal beams may introduce a great variety of problems. Attachment to timber rafters or beams is generally a simple matter which, in the ordinary way, calls for no comment, but unusual conditions sometimes arise, such as those depicted in Figs. 5 and 6. The pitch of the bolt holes in the motor base will seldom be found to correspond to the pitch of the floor beams, and ordinarily this difficulty will be met by bolting a timber platform to the latter and fixing the motor to this. Should such a method be undesirable or impossible, an alternative means employing steel brackets is shown in Fig. 5. They may have to be specially made, and almost certainly will have to be specially drilled, but the method is worth a little extra expense as it is both rigid and neat. It also permits of a fairly wide range of bolt-hole pitch, as the brackets may be placed either outside the beams or inside if the pitch of the latter is too great.

The design shown in Fig. 6 was employed where it was desired to suspend a motor from the ceiling, but at the same time to operate it in its normal vertical position. The use of structural steel would make a neater and better job than timber, but the latter is cheaper and will be satisfactory if the work is well carried out with seasoned material. It is desirable to place the motor as close to the ceiling as possible, so as to keep the vertical struts short and afford maximum rigidity. It is also well to place a pad of hair felt under the motor base, as this will minimize vibration, which, in course of time, will deteriorate any wooden structure.

Attaching to steel girders is generally straightforward work and it is, therefore, unnecessary to touch upon it here; Fig. 7, however, shows a convenient form of bracket which may be employed where an extension of the girder flange is necessary.

The increasing use of concrete in buildings introduces difficulties in motor fixing, which must be met by special means. If the architectural and engineering design can be worked in together, bolts or sockets can be placed in the ceilings as the building work proceeds, thus saving trouble and expense. This, unfortunately, is not always possible and more often the erector has to deal with a finished building. Figs. 8, 9 and 10 illustrate methods which

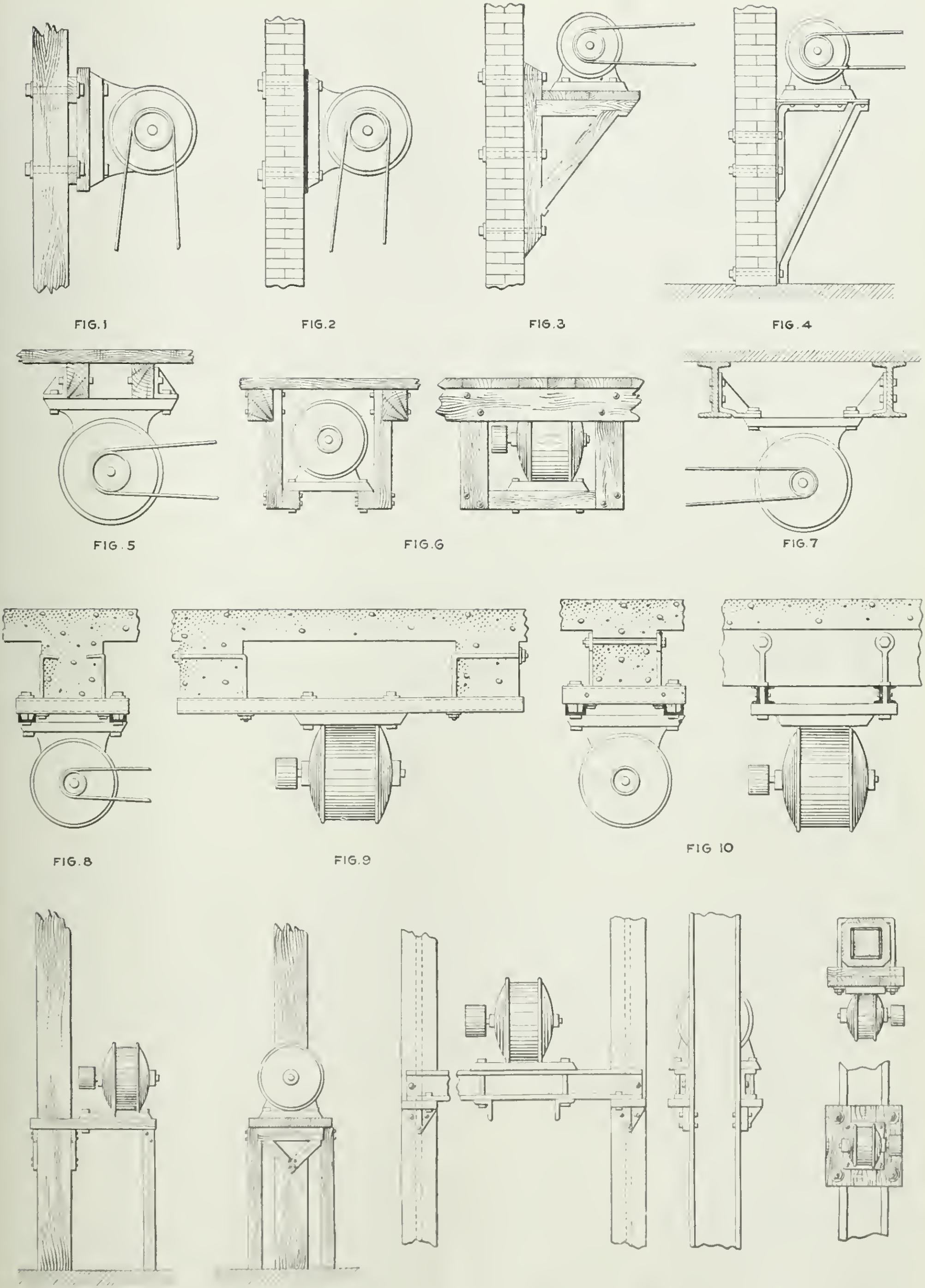


FIG. 1 FIG. 2 FIG. 3 FIG. 4

FIG. 5 FIG. 6 FIG. 7

FIG. 8 FIG. 9 FIG. 10

FIG. 11 FIG. 12 FIG. 13

Various Methods of Suspending Motors

have been employed in the attachment of motors to concrete beams. The arrangement shown in Fig. 8, which involves the use of ¾-in. hooked bolts sunk and grouted into specially drilled holes in the concrete, is suitable for light weights and small powers. The cradle is built up of channel iron in the manner shown, but may be equally well constructed of timber if preferred.

Fig. 9 is a design suitable for larger powers, L-bolts being employed, but it is inferior to the method shown in Fig. 10, which is strong enough to meet any ordinary case of ceiling suspension. Eye-bolts are used in conjunction with a bolt piercing the concrete beam. The stringers are formed of iron channels placed back to back and the cross-pieces which directly support the motor are also of channel section. These will probably not be required in every case, for if the size of the motor base permits, it can be bolted directly to the main stringers, thus economizing in height, material and labor. One or other of these designs modified to suit the actual conditions should meet all ordinary cases of ceiling suspension from concrete beams.

In the attachment of motors directly to columns or to structures supported by columns, the weight and horsepower of the motor and the nature of the columns must be taken fully into account. Fixing direct is only advisable where small powers are concerned and in the case of timber beams a small wooden bracket is easily constructed. It is safer, however, to strengthen the arrangement by the addition of vertical supports, and a column bracket designed on these lines is illustrated in Fig. 11. Here the weight is divided between the column and the legs of the bracket, which should be tied to the floor or to the base of the column. Such brackets should be kept as low as possible in order to increase their stability. Brackets for structural-steel columns present no difficulty, as they are easily constructed out of angle iron and plates, the sections being riveted together and bolted or riveted to the girder flanges. It is advisable only to support comparatively small motors in this manner, and the larger sizes should be carried on stringers of structural steel, erected between two convenient columns, on the lines indicated in Fig. 12.

Attaching to concrete columns is a more difficult matter, and it is undesirable to install anything but small motors in such a location. A simple but effective method suitable for a light motor is illustrated in Fig. 13. Two U-shaped ¾-in. bolts encircle the column and a stout timber base board is thus securely bolted to it. In order to prevent slip the bolts should be sunk into the back of the column as shown; failing this, vibration will in time weaken the hold unless the motor is very small. It is obvious that the methods illustrated in Figs. 8, 9 and 10 may also be applied in securing attachment to concrete columns if the details are suitably modified.

⁂

Direct and Indirect Labor—We often take offense at something merely because the thing is misnamed, says "American Machinist." "Nonproductive labor" is a term that carries with it a wrong idea. It is a misnomer. The contrast is **productive** against **nonproductive.** And the natural conclusion is that work so classed should be dispensed with merely because it is labeled "nonproductive." The substitute terms that are fortunately growing in favor are "direct labor" and "indirect labor." They are descriptive and convey no wrong idea. Therefore say direct instead of productive, and indirect instead of nonproductive labor.

Observations of Boiler Water Columns

By R. N. Robertson

The following observations were made on one of a battery of seven boilers in an effort to account for the large amount of water that passed over to the engines whenever there was a sudden heavy overload. This took place with apparently a moderate amount of water in the boilers.

The original arrangement of the water column with the connections is shown in Fig. 1. The later arrangement is shown in Fig. 2. Since making the original observations of the apparent water level as shown by the two glasses on the original installation, all the glasses have been changed and connected as shown in Fig. 2, and relying upon the water level as indicated by the present arrangement very little water has been carried over.

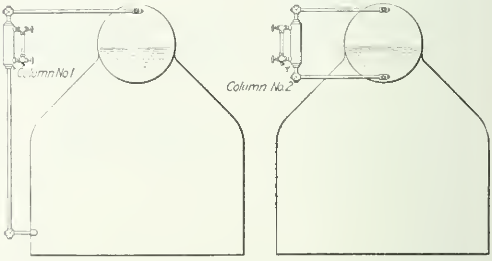


FIG. 1. FIG. 2

Methods of Connecting Water Columns

OBSERVATIONS

Gage Pressure, Pounds per Sq. In.	Water Level Col. No. 1, Inches	Water Level Col. No. 2, Inches	Remarks
Boiler cold ...	3¾	3¾	Fire just started.
26	3⅛	5¼	
40	3	5½	
50	2¾	6	
60	2¾	6	
80	2½	6¼	
100	2	6½	Boiler not on the line.
100	1¾	6¾	Boiler working on the line.

The tabulated observations show that column No. 1 (as originally installed and connected) indicates about 5 in. less water than is actually in the boiler drum under working conditions.

A calculation based on the temperature of the boiler water at 100-lb. gage pressure (atmospheric pressure about 12 lb. abs.) and a temperature of 100 deg. F. in the lower connection to the water column, indicates that No. 1 column (as originally installed and connected) will show about 4.6 in. less water than is actually in the boiler. This is due to the difference in temperature of the water in the upcast leg of the boiler and that in the downcast leg from the bottom of the water column. In this case the apparent water level was 3½ ft. above the point at which the downcast leg from the water column entered the water leg of the boiler.

The observations emphasize the necessity of making the connections to the water column, and especially the bottom connection, as short and direct as possible. Particularly should there be avoided long vertical pipes leading from the bottom of the column and making connection low down on the boiler.

Apparently No. 2 water column is a little affected by the circulation in the boiler, due to rapid steaming, as the apparent water level rose 1/4 in. when the boiler went into active operation on the steam header. This circulation also apparently affected No. 1 column also but, as might be expected, in the opposite direction, the water level in this column dropping 1/4 in. when the boiler began to steam freely.

At the time the observations were made column No. 1 and column No. 2 were simultaneously in use on the same boiler.

⁂

Refilling Commutators

By Norman G. Meade

SYNOPSIS—Directions for making and assembling commutator segments from scrap copper, with the tools ordinarily available around a plant.

⁂

Where there are many direct-current motors in use, refilling of worn-out commutators becomes a factor of considerable importance. The delay in securing new parts from manufacturers, especially if the machine is several years old, often causes serious annoyance. This consideration and the matter of reducing the cost of repairs led the writer to devise a simple method of refilling commutators at a comparatively small cost, utilizing scrap copper wire for the raw material.

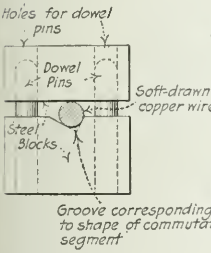


FIG. 1

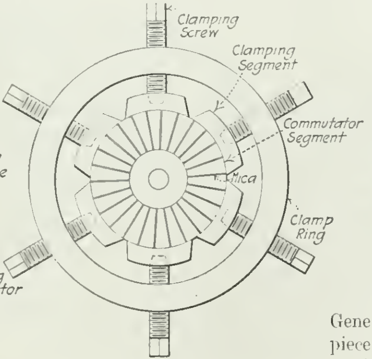


FIG. 2

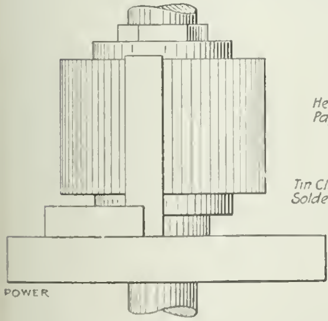


FIG. 4

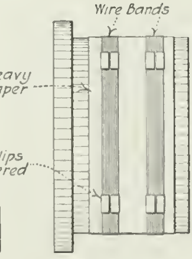


FIG. 5

Method of Forming and Clamping Segments

The first operation was to dismantle the old commutator, being careful to preserve the insulating rings at the ends, if possible. From one of the worn segments the actual shape of a new segment was determined and a sketch drawn. This was turned over to the die-maker, who made a die similar to the one shown in Fig. 1, the recess or groove corresponding to the shape of the desired segment.

From the scrap pile discarded copper wire of the proper size was selected and the insulation burned off, which, at the same time softened the copper. The wire was then cut into lengths a little greater than the required length of the finished commutator and the die and the copper stock were taken to the blacksmith shop. The upper steel block of the die was raised sufficiently to insert a piece of the copper and the die placed under the steam hammer. Generally one or two blows were sufficient to shape the piece of wire and the new blank was ready. The hammering process hardened the copper sufficiently for use.

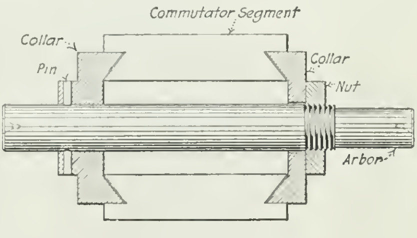


FIG. 3

A suitable clamping device is necessary for assembling and holding the segments in the proper form while boring out the center and turning the grooves in the ends. A serviceable clamp, shown in Fig. 2, can be made from odds and ends always found around a shop. From sheet "micanite" the oblong pieces of insulation should be cut and the segments and insulation assembled in the ring clamp and tightened up. The clamping ring is next placed in a lathe chuck and the ends and interior of the segments finished.

If the shell of the old commutator cannot be conveniently used, a temporary arrangement for holding the segments can be made as in Fig. 3, which is an arbor with a tight and a loose collar that conform in shape to the finished ends of the segments. This device should be attached to the assembled segments before the clamping ring is loosened. The arbor with the segments is then placed in a lathe and the outside of the segments finished. The segments should be turned down to within about a half inch from one end, so as to leave a shoulder in which slots can be cut to receive the lead wires.

The arbor and segments should then be transferred to a milling machine for cutting the slots in the shoulder. Before turning the outside of the segments, it is well to make sure that all are parallel to the axis. This can be accomplished as in Fig. 4. Insert one end of the arbor into a hole in any true surface and place a try-square as indicated. By sighting along its edges, one can easily determine whether the segments are in line. If not, they can be driven into position by slightly loosening the clamping nut and using a small cold-chisel and a light hammer.

It is advisable to make up several sets of segments at one time, so as to have a reserve stock; the assembled segments can be held in shape for instant use by banding them as in Fig. 5. The banding is done after the turning is completed, but before the segments are removed from the clamping collars on the arbor.

By following this method of refilling, new commutators can be made at small cost and without delay.

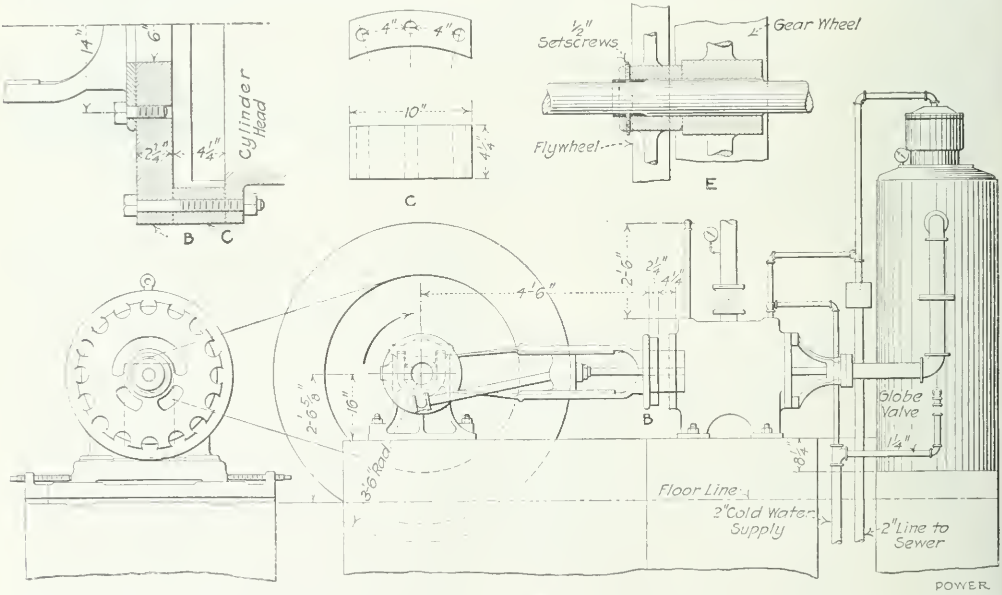
⁂

Adapting Old Equipment to New Use

By D. P. Morrison

In any large establishment, changes in requirements or load often render an individual unit unsuitable for further use in a given location, and the problem of fitting such equipment to other needs and locations is often difficult of solution. The following is an example:

A steam-driven compound air compressor having 12-in. duplex steam cylinders and air cylinders of 11¼- and 18¼-in. bore by 14-in. stroke, was released. A shortage of air in the car-repair yard elsewhere required increased capacity, but as no steam was available there, this compressor was useless unless some other drive could be arranged. An electric drive for the compressor was worked out, as illustrated. In the original machine the steam cylinder on each side was between the air cylinder and the frame girder, and owing to the difference in diameter between the steam and air cylinders, the girders could not be attached directly to the latter. It was necessary to design a yoke *B* to which the girder could be bolted through extension blocks *C* to the air cylinder. With the rods cut to suit the new position of the air cylinders, the machine was ready for the motor drive.



The Compressor with Motor Attached

It was decided to use a silent-chain drive of sufficient size to overcome the difficulties often had in compressor work and reduce the speed to 125 r.p.m. to favor the equipment and keep the horsepower down. The 580-r.p.m., three-phase, 60-cycle motor gave a ratio of about 4.6 to 1 and a chain speed of about 1450 ft. per min. A 1½-in. pitch chain 9 in. wide at this speed is ordinarily rated by the builder at 100 hp., but this figure was not considered liberal enough for a compressor drive, so a chain 14 in. wide and sprockets without spring centers were put on.

Another problem was to secure room for the sprocket of this width between the flywheel and main bearing without making another crankshaft, because the large part of the shaft was not long enough to accommodate both wheels. A collar or sleeve was shrunk on the shaft and turned down to the large size of the shaft. After the hub was clamped on, it was held in place by three ½-in. setscrews on each side, extending through the sleeve.

The control is of the unloading type in which the low-pressure intake is entirely closed and the high-pressure discharge is opened to the atmosphere. This governor unloads the motor to 15 per cent. of full load and is set for a ten-pound variation. For example, it unloads at 90 lb. and runs unloaded until the pressure drops to 80 lb., when the compressor again takes the load.

This compressor has now been in continuous operation, ten hours per day, for four months without any evidence of distress; in fact, its upkeep is less than for a similar steam-driven machine.

⁂

A Test for Pump Valves—Leaks in pump valves will show by the pump failing to maintain a vacuum within itself when the suction valve is closed.

The Universal Unaflow Engine

SYNOPSIS—An engine using the una-flow principle of central piston-controlled exhaust ports, but having an auxiliary single-beat poppet exhaust valve about midway between the end and the middle of the cylinder to avoid excessive compression when the engine runs noncondensing. The auxiliary valve cuts in automatically if the vacuum is lost and ceases operating when it is restored. Steam rates of 16.78 lb. with moderate superheat and 19.16 lb. with dry-saturated steam noncondensing are claimed.

⁂

The una-flow engine has been in use in Europe for several years, and the economy obtained by it, together with its simplicity, has led to its rapid adoption abroad. The principle involved has for its object the elimination of one of the greatest losses in reciprocating steam engines.

With the una-flow engine, the steam enters the cylinder at the ends, after passing through steam-jacketed heads; and, after cutoff and expansion have taken place, it is exhausted through ports arranged around the center of the cylinder, which are uncovered by the piston at the end of the stroke. The steam has, consequently, a flow in but one direction—hence the phrase "uni-directional flow," of which "una-flow" is a derivative.

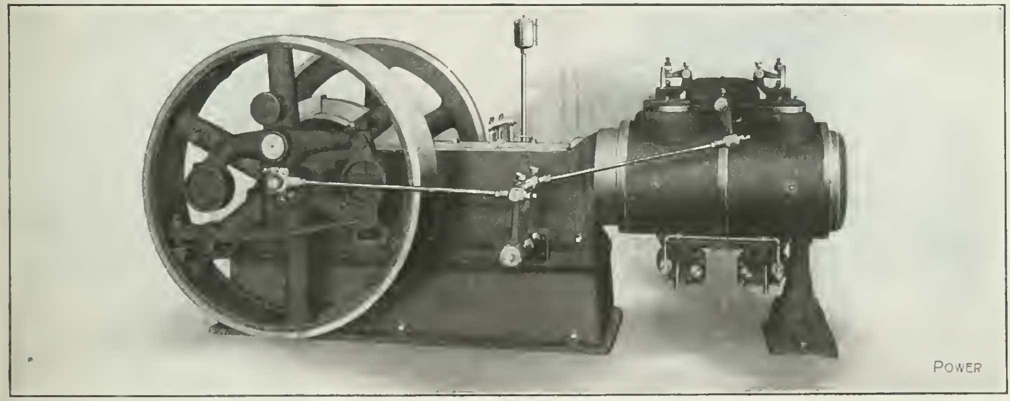


FIG. 1. THE UNIVERSAL UNAFLOW ENGINE

In the counterflow engine the steam returns on its path at the end of the stroke and is exhausted at the same end of the cylinder at which it entered. By this method, the cold expanded steam of considerable volume washes the cylinder walls and head during fifty to seventy-five per cent. of the return stroke, thereby cooling them to such an extent that the high-pressure steam, when it is again admitted, is cooled or condensed by coming in contact with the head and clearance spaces of the cylinder which have just been cooled by the expanded exhaust steam.

It is this cooling effect that causes what is termed "initial condensation" which is largely eliminated in the una-flow engine, where the ends are kept hot and the center or exhaust belt cool.

It was to remedy this fundamental defect of the counterflow engine that successive expansion stages were resorted to, as in compound or triple-expansion engines. Superheating has also been employed, but it cannot be effected without some cost in installation and operation and it does not entirely remove the difficulty.

By avoiding the cooling of the clearance surfaces in the design of the cylinder itself, it is possible to obtain in a single cylinder as many expansions, with as good or better economy, as can be obtained in a compound or triple-expansion engine; and the practical advantages of the simpler valve gear, the smaller amount of cylinder and gear lubrication required and the higher mechanical efficiency will appeal to all engineers.

In the una-flow engine as ordinarily built, compression begins as soon as the piston covers the central exhaust ports and continues during some ninety per cent. of the stroke, which, even with small clearances, does not cause it to mount above the initial pressure so long as the engine is operated condensing, with a fairly good vacuum, as is the almost universal practice in Europe.

If the engine should be operated noncondensing, however, the compression, starting almost at the beginning of the return stroke and with atmospheric pressure instead of vacuum in the cylinder, would become so excessive as to be detrimental to the engine unless large clearances were provided.

In America, where some ninety per cent. of the steam engines installed operate noncondensing, modification was necessary to meet this condition, and the engine under review, and shown in Fig. 1, was designed by L. G. Skinner, of the Skinner Engine Co., Erie, Penn., for this purpose. Its essential feature is an auxiliary exhaust valve at that point in the cylinder where it is usual to start compression in a counterflow engine.

The una-flow principle is not sacrificed nor its effect vitiated, as the volume of expanded steam ready for exhaust is still emptied from the cylinder through the central exhaust ports, and only the vapor at atmospheric pressure remaining in the cylinder between the central exhaust ports and the auxiliary ports is removed through those ports instead of being compressed into a large clearance.

The valves are not placed at the ends of the cylinder,

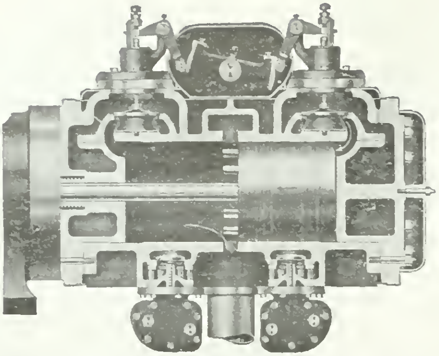


Fig. 2. Head End: Admission on Dead Center. Frame End: Exhaust through Central Ports

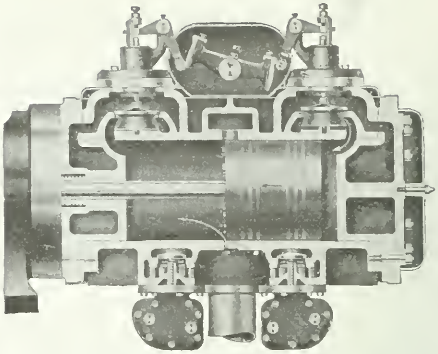


Fig. 3. Head End: Full Opening of Valve. Frame End: Exhaust through Central Ports about to Close

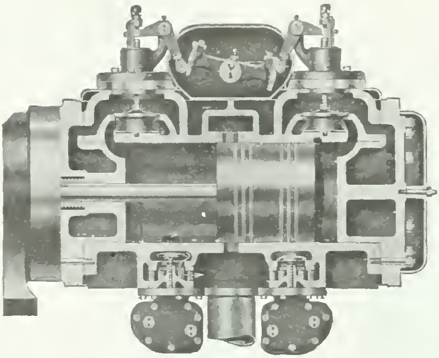


Fig. 4. Head End: Closing of Admission Valve and Beginning of Expansion. Frame End: Displacement of Trapped Vapor through Open Auxiliary Exhaust Valve

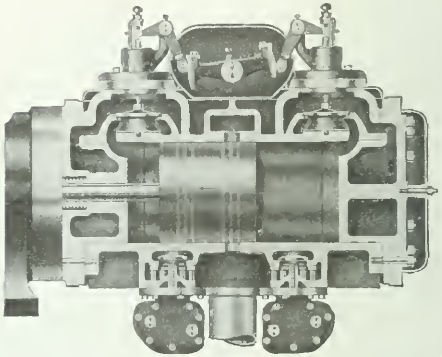


Fig. 5. Head End: Continuation of Expansion. Frame End: Commencement of Compression by Piston Covering Auxiliary Exhaust Port

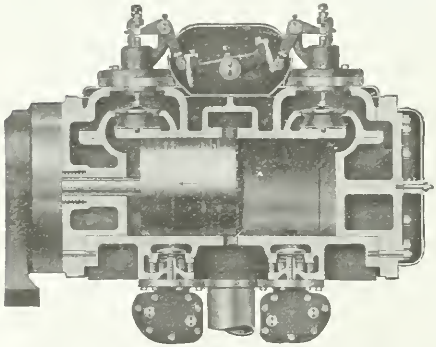


Fig. 6. Head End: Beginning of Exhaust through Central Exhaust Ports. Frame End: Continuation of Compression

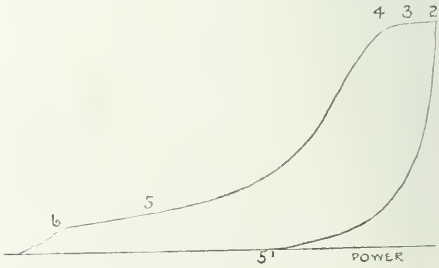


Fig. 7. The Numbers Correspond with Those of the Sections Showing Positions of Piston and Valves at Points Indicated

The Universal Unaflow Engine Operating Noncondensing for this would cause the trapped steam to sweep the entire length of the cylinder and cool the hot ends with its washing effect.

That the una-flow principle is still effective with this arrangement is proved by the fact that the Universal Unaflow engine, according to the builders' statement, gives practically as good economy at one-fourth load as at full load, showing that the effects of cylinder condensation have been largely eliminated.

The action of the engine, operating noncondensing, is described in Figs. 2 to 6, while the numbers on the accompanying indicator diagram, Fig. 7, correspond to the numbers of the sections and indicate the position of the head end of the piston in each one of these cuts except the 5′, which refers to the condition in the frame end when the piston and valves are as shown in Fig. 5.

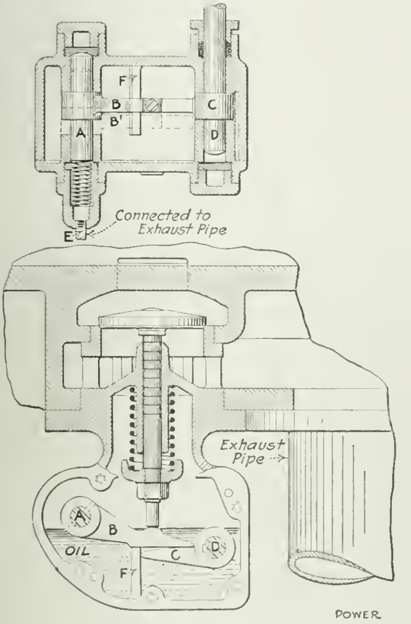


Fig. 8. The Auxiliary Exhaust Valve Gear

In Fig. 2, the engine is shown on the dead center, with admission taking place on the head end; and at the frame end, exhaust continuing through the central port. The auxiliary exhaust valve is still closed. In Fig. 3, just as the piston is about to cover the central exhaust ports, the auxiliary valve commences to open. Notice that this opening is accomplished when there is exhaust pressure on both sides of the valve, and the valve opens against no difference in pressure.

In Fig. 5, the piston has passed over the edge of the auxiliary port and compression has commenced, although the auxiliary valve is still open and does not close until the piston has nearly reached the end of its stroke. Hence, the valve closes with exhaust pressure on both sides and again against no difference in pressure. The fact that the auxiliary valve both opens and closes under balanced pressure permits the use of a single-seated poppet valve, which involves less clearance than a double-seated valve which the builders would have been forced to use if the valves were to open and close against pressure. The clearance of the single-seated valve is claimed by the builders to be less than one per cent. in most of the engines which they are building. It also allows the use of an extremely simple and compact driving gear free from excessive stresses. A spring of but small tension is required; in fact, the valve has been operated without any spring whatever. The spring is telescopically mounted upon the valve in order that the entire exhaust gear may be above the floor and accessible.

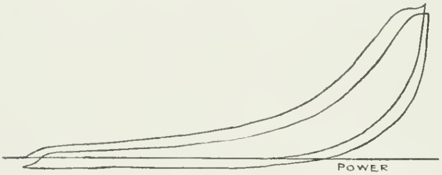


Fig. 9. Condensing and Noncondensing Diagrams Taken 10 Seconds Apart

When operating condensing, the auxiliary exhaust valves are automatically disengaged and remain closed at all times unless the vacuum should break, whereupon the valves are automatically placed in operation and the engine becomes a noncondensing una-flow engine again.

Operating condensing, the Universal Unaflow has a steam rate comparable to that of the European una-flow engine, with the advantage that excessive compression is automatically prevented if the vacuum should fail. It is this feature of automatically accommodating itself to both condensing and noncondensing conditions which led the builders of this engine to name it the Universal Unaflow.

Fig. 8 shows the construction of the auxiliary exhaust valve gear. *A* is the shaft supporting the idler *B*, which is operated by the shear cam *C*. This cam is operated by the engine valve gear which is connected to the shaft *D* on the outside of the cam box.

Fig. 10. Friction Diagrams Showing 1.19 Per Cent. of Rated Load

When the cam *C* raises the idler *B*, the latter raises the single-beat exhaust valve, the stem of which projects within a short distance of the idler *B*. The spring around the valve stem has only enough tension to insure quick closing when operating at high speeds. The shear cam is so designed that there is practically no sliding action on the idler. Both cam and idler are of steel and are immersed in oil.

The pocket *E* is connected to the central exhaust port by means of a small pipe, and the function of the spring in this pocket is to keep the idler, through its attached shaft, in register with the stem of the valve and the cam *C'* directly underneath.

When the vacuum reaches a predetermined point, it overcomes the tension of the spring in the pocket *E* and draws the shaft into the pocket. This in turn shifts the idler to the dotted position *B'* and out of register with the cam *C'*, so that, while the cam still moves as before, it cannot lift the valve.

Therefore, the valve remains closed when there is a vacuum in the exhaust pipe, and is kept tightly closed by the force of the vacuum itself exerted on the under side of the valve. The pressure in the cylinder acting on top of the valve also tends to keep it closed.

The bridge *F* acts as a slide and a rest for the idler and holds it at the proper height so that if the vacuum should fail, the spring now asserting its force in pocket *E* would slide the idler between the cam and valve stem, whereupon the auxiliary exhaust automatically begins its functions.

The indicator diagrams reproduced in Fig. 9 were taken from a Universal Unaflow engine operating both condensing and noncondensing. They were taken about ten seconds apart—the time required to break the vacuum.

Operating condensing, it will be noticed that the compression begins at 10 per cent. of the return stroke, because the auxiliary exhaust valves are not in operation; and when operating noncondensing the compression has been delayed by the means just described.

Labyrinth or water-groove packing is used upon the auxiliary exhaust-valve stems. The admission valve gear is extremely simple, consisting of one rocker-shaft, with case-hardened steel cams operating in an oil bath, and controlling the operation of the valve by means of forked levers on which are mounted rollers bearing against the cams.

Double-beat poppet valves adapted to steam of high and low pressure, saturated and superheated, are employed. Instead of mounting the spring above the valve, as is customary, it is telescoped in the housing, but, of course, not in the steam space. All adjustments of the valve, cams and rollers are made by one setscrew located above the lifters.

It was the builders' motive to design a valve gear capable of operation at high speeds. This involved simplicity, and there are but twelve joints in the combined admission and auxiliary exhaust gear.

The first engine with this gear was operated, off and on, for nearly a year in the builders' shops, at a speed of 275 r.p.m. It was then placed in service, and has now been in operation nearly two years on a night-and-day schedule, at a speed of 257 r.p.m. without repairs or renewals.

The mechanical efficiency of the engine is remarkably high. Fig. 10 shows friction diagrams taken from the 160-hp. engine illustrated in Fig. 1, operating at 232 r.p.m. The indicated horsepower was 7.19, showing a friction loss of 4.49 per cent.

A recent test of a 400-hp. engine showed a friction loss of only 9.06 i.hp., which is equivalent to a mechanical efficiency of 97.735 per cent.

The economy of this engine when operating condensing is said to be about the same as that of the European engine, while the builders claim a remarkably flat curve for it when operating noncondensing. Tests with saturated steam at 126 lb. pressure have shown a water rate as low as 19.16 lb. per indicated horsepower-hour at one-half load.

With steam at 159 lb. pressure, superheated 93 deg. F., a 13x16-in. engine operating noncondensing, when tested by the purchaser's consulting engineer, gave a steam rate of 16.78 lb. per i.hp.-hr. at one and one-fourth load, and 17.3 lb. at one-fourth load, showing a practically flat curve throughout the load range.

All of these tests were made without any special preparation of the engine, one test having been made within seven hours of the time the steam and exhaust pipes had been connected to the engine on the builders' test block.

Several thousand horsepower of these engines are now in active service—a few on night-and-day schedules. They are built in center-crank and side-crank types, in sizes ranging from 150 to 750 hp. The Skinner governor, automatic oiling system and general design of bed and parts are used.

⁂

Heating and Ventilating a Dye Shop

By H. M. Nichols

The problem of properly heating and ventilating a dye shop during the winter months presents unusual difficulties, and as a consequence the atmosphere of many dye rooms in otherwise well regulated plants is damp and icy and filled with vapor during the winter months. Under this condition, it is not surprising that the efficiency of these departments falls off materially.

It was the writer's good fortune to be well acquainted with a plant in which this vexing problem had been so successfully solved that this department was as well heated and ventilated throughout the entire year as any department in the plant.

As is well known to those familiar with dye-house ventilation, the greatest trouble arises from the condensation of the vapor which is continually rising in great clouds from the dye kettles and tubs. When the steam comes in contact with the cold air which is flowing in from the doors, windows, etc., it condenses, rapidly sinking toward the floor and thus obscures the view.

In the establishment referred to, this difficulty was overcome by the installation of a double fan system. One fan was put in to blow heated air along the floor line, while another was employed as an exhauster near the roof to discharge out of doors. With this combination, the escaping steam was caught by the up draft of the incoming heated air and carried above the heads of the workmen, where it was caught up by the suction of an exhaust fan. The hot air was taken from the boiler room through a conduit to the dye shop at a nominal cost for operation beyond the power necessary to drive the two fans. In most plants, however, it would probably be necessary to heat the air by means of a steam coil.

⁂

Copper-Steel—The use of about ½ of 1 per cent. of copper in steel greatly increases its resistance to corrosion in acid. That it makes it a better material for use under general conditions and better able to resist the natural corrosion from exposure to the weather, has yet to be demonstrated.

⁂

Application for New Jersey licenses—Engineers and firemen of New Jersey should immediately request applications for licenses if they wish to obtain them without examination. All applicants filing applications after Dec. 31 will be subject to examination. Watchmen who handle boilers carrying over 10-lb. pressure are obliged to have firemen's licenses.

Municipal Electric Works, Schaffhausen, Switzerland*

SYNOPSIS—Water which would run to waste during the night and Sundays is made to pump water from the tail race to an elevated reservoir, thus storing energy to meet the day demand. The plant has seen the development from rope to electric transmission and from an efficiency of 39 per cent. to creditable modern performance.

⁂

The article treats of the increase in capacity of a hydraulic power installation on the Rhine opposite the city of Schaffhausen, Switzerland. The installation in question existed some forty years ago as a plant of three hydraulic turbines utilizing the energy of an artificial head in the river; two of those turbines delivering their power across the river and for about 2000 ft. up-stream along its right bank through the medium of a, at that time notable, system of wire-rope transmission for the operation of various industries in that city, and the remaining turbine furnishing power through a diagonal line of shafting to a consumer at the top of the slope of the left bank of the river.

Under increasing load the multiplicity of bevel gears and shafts absorbed a very large share of the attendance and maintenance costs, representing as well an important power loss, and as this first installation, Station A, was no longer able to meet the demands on it for power, the water-works company in the years from 1887 to 1890 erected the lower plant, Station B, equipped with five Jonval turbines of 300 hp. each at 48 r.p.m., and, like the other turbines, fitted for rope drive. Even at that time two of these five turbines were used for electric-power transmission as they operated two rope-driven, direct-current generators for delivery of their energy through an overhead line to a spinning mill some 2200 ft. distant, and the second step toward electrification was made when the city of Schaffhausen leased two of the remaining turbines for the operation of alternating-current machines to supply the city lighting and street-railway systems, while in 1900 new turbines of 350 hp. each and, as in Station B, with bevel-gear-driven, three-phase current generators, displaced the old rope drive in Station A.

Intake and other conditions resulted in perceptible head losses which, taken in conjunction with the faulty suction effect of the cylindrical housing of the turbines, reduced the efficiency of Station B to 39 per cent. Improvements resulted in raising the turbine efficiency alone by about 60 per cent., of which, however, 11 per cent. at low water and even 19 per cent. at high water, disappeared again in the form of head losses, so that only through a complete rebuilding of the station could it have yielded a service commensurate with the available water and the conditions of head. Such a rebuilding received the sanction of the city authorities in 1905 and 1906 in that they decided on redesigning Station B on an equipment basis of five 550-hp. turbines, including one reserve unit, and to erect Station C on the right bank of the river with a view to securing throughout the night hours the energy of a volume of water up to then unutilizable. This last mentioned station contains electrically driven pumps operated by current generated in Station B and delivering their water at night into a high-level storage reservoir to be drawn thence by day for conversion into electric current by means of high-pressure turbines and generators. Station C is designed for the reception of four 1000-hp. units, of which two were put in service in 1909.

The fall at the locality in question varies from, say 12.13 ft. at high water to about 15.74 ft. at low water. The early turbine installation of Station B, at the conceded minimum water volume of 1400 cu.ft. per second, yielded under the most favorable conditions of fall a maximum of about 1200 hp., measured at the turbine shaft. In consequence of the unfavorable intake conditions, such as a contraction of its cross-section and two right-angle bends, added to the hindering effect of the two-part gates for shutting off the turbine chambers, the hydraulic efficiency of the plant was seriously reduced as, on a basis of 1400 cu.ft. of water per second with the referred to fall of 15.74 ft., using modern turbines and eliminating the mentioned head losses, it is possible to develop 2000 hp. It was, therefore, decided to install five turbines of a normal 550 hp. capacity each in place of the former 300-hp. units, one to act as a reserve, and to improve the intake so far as permitted by local conditions. The intake grating was placed ahead of the gates and its flow cross-section materially increased. To utilize to the best advantage the flow velocity of the water in the intake channel, and as far as possible to use the present turbine chambers, these latter were built of spiral form whence the former swirling action and whirlpool effect were much lessened, the water delivery made more favorable in spite of the relatively small channel and a more rational use of the fall permitted.

The duplex Francis turbine adopted utilizes the conditions of head to a degree which it would have been impossible to attain with the simple turbine.

The surplus power development of the low-pressure Station B, available during nights and Sundays, determined the capacity of the high-pressure storage installation, as may be seen from the following: Of the present duty of about 3050 hp. available from the two stations on the left bank of the river there are used during nights and Sundays for light and power approximately 550 hp., leaving for pumping purposes 2500 hydraulic hp. for Stations A and B, or, say 2000 electrical hp. at the motor shafts of Station C. With this power 88,250 cu.ft. per hour can be delivered into the high-level reservoir, so that to fill it requires 30 hours; a length of time readily available between Saturday evening and Monday morning.

From the foregoing the following water values are obtained as of the storage system:

	Cu.Ft.
Reservoir storage capacity	2,647,500
Less for losses and reserve	176,500
Leaving normally on hand	2,471,000
Pump delivery during five week-day nights	5,295,000
Thus affording for six days	7,766,000
Or for one working day	1,294,300
Using for the maximum lighting load of 1000 hp. during 12 hours	465,960
There remains for power purposes	828,340

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*Translated in abstract by William F. Monaghan from a reprint pamphlet of a contribution by Ing. H. Gelser to "Schweizerischen Bauzeitung," Vol. LIV., No. 25, 1910.

This amount of water suffices for 9800 hp.-hr. per day, or 980 hp. for 10 hours.

As for Stations A and B, the water for the operation of Station C is taken from above the dam, but unlike them Station C does not return its tail water to the same source, and hence, in effect, does not draw energy from the Rhine. This, at first sight, seeming paradox is explained by the before mentioned utilization of surplus power for the high-level storage of water afterward used to energize the station and then so discharged as to still be available for another local concession, a water right which had to be considered not in any further power development but during the rebuilding which was done. This arrangement permitted the supply for the storage reservoir to be pumped from the sluice way leading to the other concession, and at such hours and over such period that the amount at any time did not infringe on other local water rights.

The installation is interesting as an example of the conversion into useful effect of previously unutilized energy.

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., does not see how the barometer gets in on all tests of condensing plants or why it need be consulted in the case. Chief Teller makes it look like an ordinary vacuum gage.

*

"Tell me, Chief, what is a barometer, and how does it get into every statement of conditions of tests of condensing engines?"

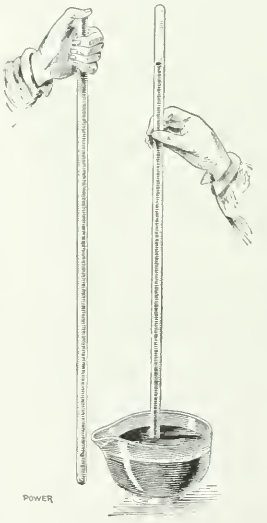
"Barometer, my boy? Just another name for vacuum gage—it's made up of two words meaning 'weight' and 'a measure.' If you operated an engine against a back pressure above the atmosphere, Will, you would use a steam gage to indicate it. If below the atmosphere, a similar gage, slightly modified, will answer for ordinary purposes. But for greater accuracy and finer graduation, it is necessary to use a gage more sensitive.

"I'm going to give you a brief history of the barometer; it will help you to get the idea clearly, and it also is a reminder of what was accomplished by some of the old-timers as compared to some of us who think ourselves *it*. Torricelli invented the barometer in 1643. He used a glass tube about 33 in. long, and closed at one end. He completely filled it with mercury, then put his thumb over the open end and inverted the tube in a cup of mercury. When he removed his thumb, the mercury dropped from the upper end for some distance, but remained at about 30 in. above the level of the mercury in the cup. There could be no air in the tube above the mercury, because it had been filled and none could reach the space through the mercury after the tube was inverted.

"This proved that there was pressure on the surface of the mercury in the cup sufficient to support the column of mercury 30 in. high in the tube, on the surface of which there was no pressure. It was then a simple matter to ascertain the weight of such a column of any height having an area equal to one square inch in section, by filling a tube and weighing it. It was found that 30 in. weighed 14.7 lb. This, of course, is atmospheric pressure. In this manner Torricelli established and proved that air had weight and thereby exercised a pressure on everything surrounded by it, and that its pressure varied according to its density and the elevation. At sea level it is spoken of as a 30-in. pressure, but if the air is filled with water vapor, which is lighter than dry air, the barometer is said to 'fall.'

"The effect of elevation was tested soon after Torricelli's discovery by a Frenchman named Pascal, who carried a barometer to the top of a mountain and found that the mercury in the tube fell several inches.

"The barometers used by mountain climbers, air navigators, and others, to tell how high they are above sea level do not as a rule contain mercury; these barometers are simple sensitive pressure gages. Their construction is also interesting and instructive, and I suggest you look up the whole subject at your leisure."



Torricelli's Barometer

"Now, tell me, Chief, how is this applied to the condenser? I know by connecting the upper end of a glass tube (by a rubber tube) to the vacuum system and having the lower end immersed in a vessel containing mercury, that the tube will be partly filled with mercury, and that the inches of vacuum may be measured with a rule, above the level in the containing vessel, but how does it figure in tests of condensing engines?"

"Just this, Will; after the test you spoke of you should try the other simple test and find out what it was possible to get under the atmospheric condition. In that way, you would determine the behavior (or efficiency) of your condensing equipment and the back pressure the engine had to work against at that particular time.

"This air pressure constitutes a back pressure directly against a non-condensing engine but the slight difference in the barometric reading from day to day is such a small percentage of the total back pressure that it is not often taken into account with such an engine. With the condensing engine, however, the same difference would be a large percentage of the total back pressure. Each inch of mercury is equal to approximately one-half pound. To be exact, multiply the height in inches by 0.491, which, you see, is 0.009 less than one-half, but for practical purposes one-half is close enough. The difference between 28.5 in. and 30 in. would mean nearly three-quarters of a pound difference in the back pressure.

"All of this goes to show that for comparison and tests it is necessary to consider the barometric readings."

Editorials

Testing Out Automatic Safety Devices

If an engineer is operating a power plant equipped with safety devices, it is reasonable to assume that a certain amount of reliance will be placed upon their automatic operation. As a matter of fact, such devices are so common in power plants that it becomes natural to assume that, because they are designed to act automatically, they will always do so.

This assumption really invites accident, not because of any fault in the design or intent of the device, but because a certain condition or conditions can arise which will cause the device to become inoperative.

If a man breaks an arm it is impossible to use it freely when the splints have been removed, and it is only by exercising the muscles that the free use of the member is regained. There are certain members of safety devices that require frequent use to keep them in condition. If they fall into disuse, the operating parts become stiff in action, and there is danger that they will fail to operate when it is imperative that protection be afforded.

For instance, an engineer upon taking over a steam plant tested the safety device on the throttling governor of a small slide-valve engine, but it did not work. It had been so long since the device had operated that the movable parts were coated and caked with oil and dirt. If the engineer had not been at hand to close the throttle, in case of a runaway the engine would have been wrecked.

Had the governor belt broken during a day's run, when no one was near to close the throttle, the chances are that the real cause of the wreck would have remained a mystery.

He is a wise engineer who will use those safety devices which lend themselves to hand as well as to automatic control in handling the machinery which they should safeguard. Steam turbines are equipped with automatic-control throttle valves designed to shut off the steam in case of excessive speed. These valves can be tripped by hand, and the engineer who stops a turbine by tripping the valve has the assurance that it is in working condition.

Most engineers use the automatic valve in shutting down a unit, as they realize the importance of positive operation. If an automatic safety throttle valve is never operated until there is an emergency call, in all probability it will fail to work.

Not long ago a large steam turbine was wrecked because the automatic throttle valve failed to work. Its design was that of hundreds of other successful valves, but it was not used in shutting down the unit—in fact, it had not operated for weeks. In consequence, the valve-stem packing had so hardened and stuck that when the call for automatic safety protection came, the failure of the valve wrought disaster.

Testing out such a device is small enough in itself and takes little time, but it will probably prevent wrecking an expensive machine and seriously crippling the service.

Exit the Politician--Enter the Engineer

Engineers of all kinds will be interested in the advent of more efficient methods of municipal administration, as outlined by Henry M. Waite, city manager of Dayton, Ohio, at a recent joint meeting of engineers in Boston. Eleven months' trial of this plan of government on the largest scale thus far attempted in this country gives ample evidence that by its means a city of one hundred and twenty-five thousand people can be run on a strictly business basis, free from political interference, open to the fullest publicity, and with concentrated responsibility in the direction of every branch of the municipal service. Without discussing the merits of the city-manager plan as compared with a straight commission or the Federal form of government, it is desirable to realize the meaning of this advanced movement for the engineering profession, for more will be heard of this matter in the near future.

Fundamentally, the larger problems of city administration are closely related to engineering. Water-supply, sanitation, relations with public utilities, the conduct of municipal electric service, the scientific management of pumping plants, highway construction and maintenance, motor transportation, fire protection—these and many other issues either demand engineering advice for their proper solution or call for technical insight in their administration. More and more executive duties are being laid upon the capable shoulders of men of engineering training in connection with public affairs, and just as the great railroad systems and innumerable industrial organizations are putting engineers into the chairs of manager and superintendent, so communities with far-sighted appreciation of the analytical and constructive abilities of technical men are turning to them for help in the search for more efficient city management. The opportunity before engineers qualified to enter this field is one of the most notable that has ever presented itself to the profession.

To make a success of this work the engineer must take himself in hand and get entirely out of narrow ways of thinking and acting. In his address at Boston, Mr. Waite put special emphasis upon the importance of the engineer acquiring the ability to talk on his feet before those whom he wishes to persuade that a certain program is advisable. It is not enough to be able to write a straightforward report on a proposition, but a man must be capable of putting his ideas into words under the fire of hostile questions, and of thinking and speaking clearly under the most trying conditions. Lacking a sense of humor which can appreciate a situation without the slightest abatement in courtesy, the engineer who would enter this field had better give up the idea. In the past, probably seventy-five per cent. of the problems "put up to" the engineer have led him to go off somewhere by himself and work out a solution. This tends toward inbreeding, which, if carried to extremes, is fatal to executive direction or leadership.

The ability to look at problems in a large way, to cultivate the controlled imagination and to reason out the probable consequences of various policies and steps ought not to be difficult to the engineer, whose experience so generally calls for such qualifications, although often in a very limited field. A knowledge of materials and their strength, a thorough comprehension of the principles of mechanics, steam engineering, electricity, hydraulics, machine design, applied mathematics, and physical science as a whole will help in the administration of city affairs in many cases quite as much as being well posted in legal matters, and perhaps even more than the ability to round up votes in a given district at election time. The variety of problems which come before a city executive of the manager type is almost beyond belief; but the fitness of a man with engineering training, plus common sense and the ability to get along well with his fellows, for dealing with questions far removed from those of technical practice is being demonstrated daily.

It is only a few weeks since a great Boston charitable organization retained a consulting engineer to investigate its efficiency as a philanthropic instrument, and the resulting report, which the engineer donated out of personal interest in the work, shows that it is not only in the field of iron and steel and steam that modern engineering is enlarging its usefulness to the world.

There is a lesson for every engineer, however humble and far removed he may be from public affairs, in the broadening call upon the great profession of which he is a part for larger services to civilization, and as surely as "he that ruleth his own spirit is greater than he that taketh a city," so surely will these higher conceptions of engineering responsibility and development benefit the individual as well as the community which takes the long look ahead.

*

Our Careless Shippers

Notwithstanding all that has been said by our consuls and business agents in South American countries, our manufacturers and jobbers continue to ship their goods crated. The foreign shipper packs his wares in boxes. This carelessness must be corrected if we would hold the trade we already have in these countries, let alone extend it.

There are few harbor and docking facilities in these countries to the south of us, and this want makes it necessary for steamships to unload their goods by transferring them to lighters, and usually in heavy seas.

American houses use one- and one-and-a-quarter-inch material. Foreign shippers use two- and two-and-a-half-inch lumber, reinforcing the boxes with heavy cross-braces, screwed in, the whole being protected by bands of sheet iron placed on the exposed edges.

Our Minister to Ecuador, Charles S. Hartman, vouches for two flagrant instances of careless packing of goods shipped to Quito. First, the Quito Electric Light & Power Co. bought seven motors from one of the largest electrical manufacturers in this country. The damaged motors arrived absolutely bare of any protecting material. Second, a large consignment of machinery arrived in flimsy crates and broken in nine places. As the broken parts cannot be made in Quito, the machinery is useless and the shipper has lost a valuable customer.

Our business houses should, at the least, imitate the foreign shipper in the matter of packing goods, and we see no good reason why they cannot excel him. "This fault," says our Callao correspondent, "lies with the large as well as the small shipper. It is a wonder to me that we have any trade here at all."

That the state of war in Europe has opened to us an immense opportunity to increase our trade with our South American neighbors is undeniable. Are we to defeat the huge efforts for extended trade being made by our commercial agents, business associations and railroad and steamship companies by an inexcusable carelessless that will become criminal if longer continued?

The market has been created: let us meet the moderate requirements.

*

Getting a New Jersey License

There seems to be much misunderstanding by engineers and firemen in New Jersey as to how to get licenses under the new law of that state.

If a license is desired without having to take an examination to get it, the engineer or fireman has simply to request an application from the Commissioner of Labor, at Trenton, fill it out and have it filed on or before December thirty-first. It costs nothing to ask for the application, but the applicant is required to send two dollars with the application when it is returned to the Commissioner's office. One does not have to be a citizen to get a license.

All engineers and firemen, as well as watchmen caring for boilers carrying over ten pounds pressure, are required to have licenses. An oiler does not need one.

We understand that, even though there is a licensed head fireman in charge of the boiler room, the fireman under him must also be licensed. It is the wish of the License Bureau that each men make his own request for an application.

A charge of twenty-five cents is made for the transfer of a license from one plant to another.

A fireman may change plants as much as he pleases and does not require an examination for each change.

For engineers there are twelve classifications, and should a man change to a plant of a different class, as from a mill to a hotel plant, he must, according to the ruling of the Bureau, take another examination, for which, we understand, he pays twenty-five cents.

A man may work in a plant for thirty days without a license. No first-class unlimited licenses are being issued. The understanding is that licenses must be renewed every year at a cost not to exceed two dollars a year for renewal.

*

The explosion of the boiler at the Continental Hotel in New York City is another demonstration of the fact that in spite of all that has been said of their unaided holding power, boiler tubes ought to be flared or beaded over.

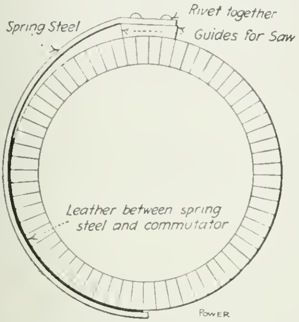
*

This week's cartoon made such an impression on one of our editors that he "orderfied" his desk, which goes to show that we know how to "take our own medicine" and "practice what we preach."

Correspondence

Guide for Undercutting Mica

The sketch shows a spring guide for the saw blade in undercutting mica on commutators. We have found this very satisfactory and trust that it will appeal to other readers.



Guide for Saw in Undercutting Mica

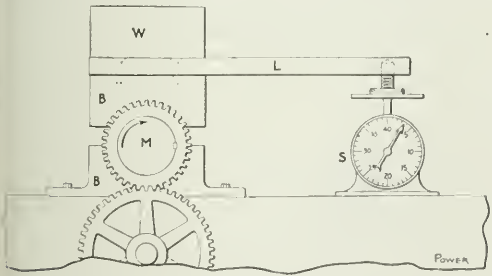
William Wayne.

Chisholm, Minn.

⁂

Testing the Value of Lubricants

The best way to determine the value of one lubricant as compared with others for the same bearing is to give it a practical test. I have constructed a machine for the purpose which will easily and quickly show which of a number of lubricants will eliminate the most friction in a bearing.



Machine for Testing Lubricants

The testing machine is composed of two brasses B, a pin M keyed to a driving gearing, a suitable lever L, a weight W and a spring scale S.

The brasses B may have brass or babbitted bearing surface, depending on which type is used in the plant. The weight W should be heavy enough to produce the same pressure per square inch on the bearing as there is on the average bearings in the plant.

When the machine is idle, only a slight pressure will be registered on the scale S, but when the pin M is rotated in the direction of the arrow, the pressure on the scale will increase directly as the friction in the bearing; in other words, the better the lubricant, the less will be the pressure exerted on the scale.

Before testing a given oil or grease, the bearing surfaces should be cleaned thoroughly and covered with a coat of the oil or grease to be tested. The lubricant should be fed in at a part of the bearing having the least pressure—i.e., between the brasses.

The pin M should be given a peripheral speed equal to that of the pins in use. A small motor which will give uniform speed makes a good drive. It is essential to feed the oil at a uniform rate and to note the average pressure on the scale; also to note the temperature of the bearing as well as that of the surrounding air for comparison in future tests.

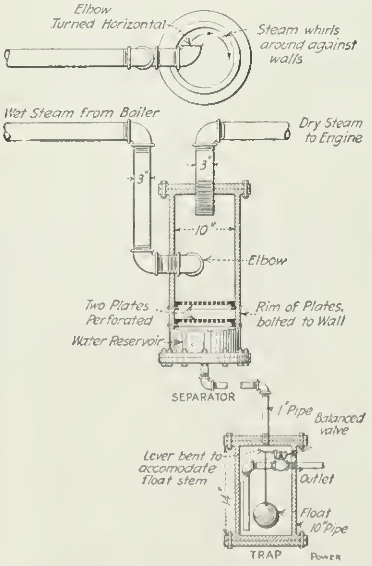
Samuel L. Robinson.

Bar Harbor, Me.

⁂

Home-Made Trap and Separator

The accompanying illustration is explanatory of my home-made separators; they insure dry steam because they are large enough to take care of sudden priming. Steam always passes through slowly as the ports are several times the size of the pipe. Maximum efficiency is



Steam Separator and Trap

obtained since the efficiency is increased as the velocity of the steam is decreased.

Centrifugal force projects the water against the walls, to which it adheres in the form of a rapidly rotating sheet, and flows continuously to the bottom of the reservoir. Once separated, under no circumstances can the water be again picked up by the steam current.

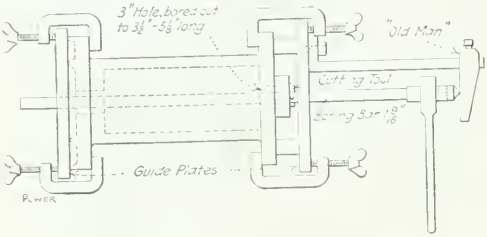
LUKE MARIER.

Fall River, Mass.

* * *

Bushing a Cable Drum

The illustration represents a cable drum which runs on a 3-in. shaft. It was badly worn and had to be bored out and bushed on a mountain, where transportation would have been costly if the work had been sent to town.



BORING-BAR OPERATED WITH RATCHET

The following rig was used: Four clamps, two guide plates, a boring bar $1\frac{9}{16}$ in. in diameter, an ordinary ratchet with Morse taper, and an "old man." All these parts were found at the camp. The bushings were ordered from town finished to size.

J. C. MATTISON.

Vancouver, B. C.

* * *

Expensive Cheap Firemen

The expensiveness of cheap firemen should be given more consideration by operating engineers and owners.

Some time ago I took a position as engineer and fireman in a sawmill in the South. The power plant consisted of two return-tubular boilers and an 18x16-in. slide-valve engine. The boilers were fed by an injector. I started on Thursday and quit on Sunday as the plant was in about the worst condition I ever saw. When I started to wash out a boiler on Sunday morning, I discovered that there were no blowoff valves; in their stead, plugs were screwed into couplings. The safety valve was on the main steam line and only one of the boilers had a stop valve. When I spoke to the owner about the blowoff valves, he said that they only cleaned their boilers twice a year (spring and fall); that they did not need any valves.

On Monday they started up with one of the handy men from the mill as engineer. I met him a few days later and asked him what the trouble was. "We had an accident," he said; "the boilers got full of water, and when the boss tried to blow them down they took him to the hospital." The owner lost the use of his left arm and the young fellow his job, simply because both were ignorant of the true condition and danger of these boilers.

On the other hand, you step into an engine room and find the equipment uptodate in every respect, everything polished to the limit and an imposing array of recording instruments on the wall—and the engine is making more noise than a trip hammer. In the boiler room you will find the firemen shoveling coal regardless of expense. Then you begin to wonder. The engineer tells you that his compound Corliss always was a steam eater.

The boss enters, looks at all the instruments and the coal chart, and then says to the engineer, "What do you fellows do with all that coal? Jim Jones did not use half as much as you fellows do. If this thing keeps up we will all be in the poor house pretty soon."

The boss has considerable money invested in this plant, but when Jim Jones wanted a raise in salary, the boss said he could not afford it as "business is poor this time of the year." So Jim quit and a cheaper man was put in his place with the results noted.

This actually happened in a plant in the Middle West containing a 3500-hp., cross-compound Corliss engine, and because they would not pay a real engineer $20 increase in salary per month they spent over $1200 more for fuel in less than seven months.

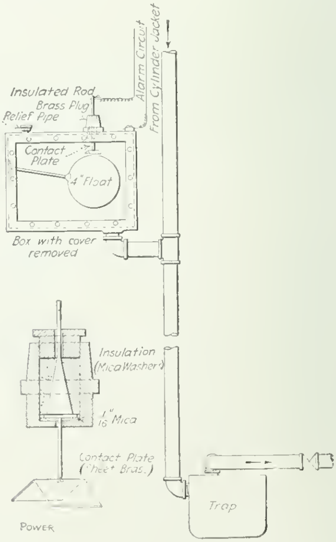
LOUIS B. CARL.

Marshfield, Wis.

* * *

Novel Trap Alarm

On our 1500-hp. cross-compound engine the steam supply line is drained through a bucket trap. It was thought advisable to safeguard the cylinder against any failure by rigging up an alarm to indicate the working of the trap. Our first alarm consisted in a trigger in connection with the bucket pivot which rang a bell every time the trap worked, but the ringing became one of the common noises of the engine room, and if it ceased was not noticed for some time. This proved that we needed an alarm that would indicate only if the trap failed to work.



ALARM ABOVE THE TRAP

We finally hit on the plan of letting the accumulation of water set the alarm off. The illustration shows how this was accomplished. A cast-iron box containing a high-pressure float was attached to the drain line above the trap as shown. When water accumulates the top of the float will touch the contact plate, thus completing an electric circuit as one wire is attached to the cast-iron box and the other is insulated in the core of the brass plug. A small pipe was attached to the top of the box and to the steam line, thus equalizing the pressure and allowing the water to back up freely into the box. The cross-section of the plug shows its construction.

The alarm is tested at intervals by allowing the condensate to fill the box. Current from the generator with a resistance is used to ring the bell and also show a red light in a conspicuous place. This eliminates the uncertainty of batteries, as in the case of the first alarm we tried.

CHESTER W. WILSON.

Paterson, N. J.

*

Liner Put in Ammonia Cylinder

The ammonia cylinder of a compressor was so badly cut that it became necessary to bore it and insert a liner. The outside diameter of the liner was made equal to the inside diameter of the cylinder to obtain a close fit.

When all was ready the water jacket was filled and blow-torches were used to heat the cylinder until it expanded enough to allow the liner to be driven in by the aid of hammers and wooden blocks. It was necessary to use a hammer only for the last three or four inches. The compressor is now giving good service.

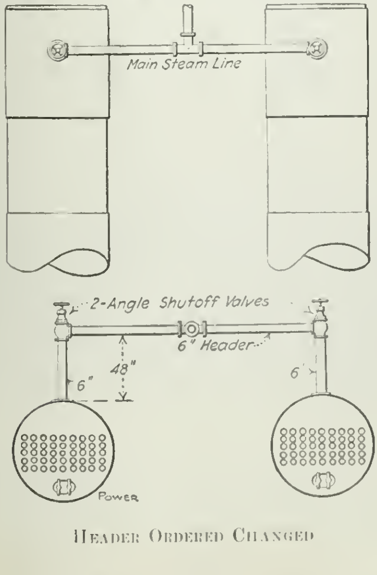
C. R. McGAHEY.

Baltimore, Md.

*

Indiana Boiler Law

There has been much criticism of the Indiana boiler laws lately. While some of it is doubtless merited, the law as passed is undoubtedly a great improvement over no law. Regarding the header connections on p. 503, Oct. 6 issue, I have no doubt that they could be improved upon, but any of them would be a great improvement over the one in the illustration; this is the actual connection between two return-tubular boilers in an ice plant in northern Indiana and, of course, the inspector ordered it changed upon his first visit.



HEADER ORDERED CHANGED

While there are many mistakes made by lawmakers, we should remember that it is far easier to see them then than in the making. Let us give credit for what has been accomplished.

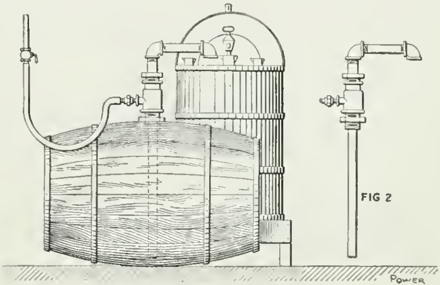
E. F. GOAD.

Chicago Heights, Ill.

*

Emptying Oil Barrels

Oil may be discharged from a barrel into the supply tank or regular container by compressed air by the use of the following rig: Screw a nipple of a size corresponding to the hole in the barrel (say 1½ or 2 in.) into a reducing tee with a smaller pipe extending through both as shown in Fig. 1. The air supply is connected to the side opening of the tee.



AIR TO DISCHARGE THE OIL

The whole rig is shown assembled in Fig. 2 and can be easily understood. Care should be taken to avoid excessive pressure which may burst the barrel; a pressure gage is useful but not essential for this purpose.

LOUIS KREUTZKAMP.

Brooklyn, N. Y.

*

Boiler-Feed-Pump Trouble

At this plant, the water level is controlled by regulators while a pump governor on the steam line limits the pressure in the feed line.

One day the water-cylinder-head gasket failed, followed the next day by the one under the discharge-valve chamber. Little was thought of this until two or three gaskets would give out in one day. Either the pump was not rigid enough, the packing unfit or the pressure too high. Heavier covers were designed and put on and other packing tried, but without success. After three weeks it was accidentally discovered that the valve on the bypass around the pump governor was open about half-way. This allowed the pump to build up an excessive pressure in the feed line and caused the trouble.

A pressure gage was afterward connected. On again opening the bypass valve to see what the pressure would be, it went up to 250 lb., with 100-lb. steam pressure, limited only by the total water pressure on the plunger equaling the total force of the steam. Had the steam cylinder been larger or the pressure higher, the water pressure would, of course, have been proportionately increased.

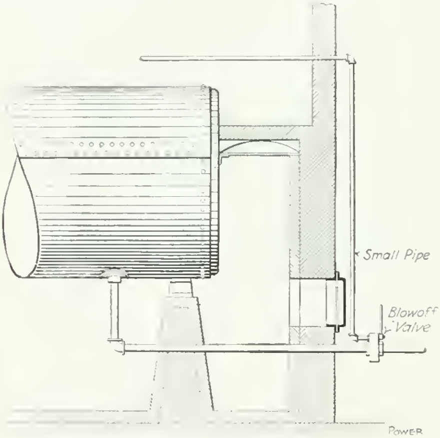
J. C. Hawkins.

Hyattsville, Md.

Keeping Blowoff from Freezing

Last winter I had considerable difficulty in keeping the boiler blowoff valves from freezing; the pipes extended two feet outside of the boiler house. It had been customary to cover the pipes with waste, etc., and slip a barrel over them, but it was not easy to get at them to blow down.

I drilled and tapped the valves for ¼-in. pipe and ran a ½-in. pipe as shown in the illustration from a steam pipe and reduced it to ¼ in. at the valve. The steam condensing in the ½-in. pipe caused a slight flow of warm water back through the blowoff pipes, which kept them from freezing.



Circulating Pipe to Blowoff

I know it costs something in coal, but it is cheaper than to have the valves burst. Of two valves which had been burst, I sent the casings to the city and had them welded by the autogenous process, so I now have two extras on hand to be used when needed.

Albert T. Rowe.

East Glastonbury, Conn.

Portable Power Plant

A great many boiler explosions annually occur in districts where portable boilers are in use, especially throughout the Southern states, where men who own sawmills take them where custom sawing is required.

One owner of a portable mill tried to "kill two birds with one stone" by acting as sawyer and engineer at the same time. He employed a boy to fire the boiler with wood waste from the mill, who knew nothing about the engine. One day the sawyer forgot all about the water in the boiler, and there was an explosion which destroyed the engine and seriously injured several people.

The most common safety devices are ignored, some boilers not having an ordinary gage-glass. A solitary gage-cock is occasionally blown; if it blows steam it is evidence that the water is getting low and more is added.

A high- and low-water alarm is seldom found on this kind of boiler, though it is easy to attach and might save many lives. Another simple safety device is the fusible plug, and boiler manufacturers often put them in whether specified or not.

The enactment of a uniform boiler inspection law is what is needed. Owners of larger plants usually have their boilers insured, which results in high-grade inspection. But the boilers in the small plants and portable boilers are not inspected, and they are often operated with defective tubes and without the ordinary safety devices.

As the insurance companies would decline to write such a risk as the average portable plant, their activity is not a complete safeguard. Let every engineer, boiler manufacturer and boiler user get busy in his own community and work for a compulsory inspection law.

G. D. Crain, Jr.

Louisville, Ky.

Removing a Brick Stack

It became necessary to remove a brick stack 80 ft. high by 9-ft. base at Waterloo, N. Y. The plan was to fell it, as one would a tree, by cutting away the two corners on one side, then driving 6x6 hemlock shores in each space, after which the remaining brickwork on that side was to be removed. Then the props were to be kicked out with a dynamite cartridge.

Just after 12 o'clock, Oct. 10, however, when all was ready, but before the button was pressed, the stack began to lean and crush the props. It went over about 15 or 20 deg., then collapsed, the inner lining of firebrick standing for a moment while the outer wall peeled off. Then all collapsed within a radius of 25 ft. from the foundation. The dynamite did not explode, notwithstanding the débris falling on it.

Original Appearance and View Just before Collapsing

Waterloo, N. Y. H. F. Brehm.

Inquiries of General Interest

Objection to Boiler Plate of High Tensile Strength—What is the objection to boiler plate having high tensile strength?

L. R. G.

Boiler iron or steel must have ductility even if tenacity is sacrificed. Beyond certain limits an increase of strength is usually accompanied by loss of ductility—i.e., the material is more brittle and is, therefore, more likely to fail from the bending action to which the plates of a boiler are subjected.

Inspecting Boiler Braces—How can it be determined whether the tie braces of a boiler are of proper lengths for taking up the stresses which they are intended to resist?

S. G.

By making an internal inspection of the boiler and ascertaining whether the braces are straight, have their ends properly shaped and secured to the shell and whether they give a clear sound when struck with a sharp blow of a hammer.

One Safety Valve to Blow Off Before the Other—Where two safety valves are used on a boiler, why is one set to blow at 90 lb. and the other at 95 lb. per sq.in.?

J. M.

One safety valve is set to blow off before the other to reduce the pressure more gradually and thereby prevent rupture of the boiler due to sudden changes of stresses of the boiler shell, and also to prevent lifting of water of the boiler from sudden reduction of steam pressure.

Advantages of Calcium Chloride Brine—What are the advantages of calcium chloride over sodium chloride (common salt) for brine used in refrigerating systems?

W. O. V.

One of the chief advantages is that the freezing point for strong solutions is much lower than for common salt brine. In double pipe systems it is better than common salt brine, for the latter may freeze and damage the cooler if the suction pressure is low. Another advantage is that calcium brine does not corrode metals as rapidly as common brine, but it is advisable to add about ½ per cent. of caustic soda to neutralize its corrosive action.

Steam in Return Lines of Vacuum Heating System—In a vacuum heating system equipped with automatic vacuum valves, how will steam get to the return lines and to the vacuum pump if the automatic valves are in working order?

L. P.

Although only water may be discharged from the radiators and drips, if the pressure in the returns or in the pump cylinder is lower than the pressure at which the water is discharged, then the condensate will vaporize until the temperature has been reduced to the boiling point corresponding to the pressure, and vapor thus formed is presented to the vacuum pump unless condensed by radiation of heat from the return lines.

Connecting Pumps with Common Suction and Discharge—When two or more pumps take suction from the same supply or discharge into the same service pipe, how should their connections be arranged for operating the pumps together?

K. W. A.

When the suctions are taken from the same tank, reservoir or pond, they should be sufficiently separated to prevent one pump from hindering the suction of another by the formation of currents or eddies. When the suctions are taken out of a common supply pipe the outlets from the pipe to the pumps should be Y branches of sizes which are in proportion to the rates of pump displacement.

For discharging into the same main the connections to the main should be by Y branches, or otherwise so arranged that the discharge from one pump will not be shut off by another, as by joining it at right angles or opposing its direction.

Adjusting Stroke of Duplex Pump—How can the stroke of a duplex pump be shortened or lengthened? R. E.

The stroke can be shortened by reducing the amount of "lost motion" between the steam valves and their stems. This can be effected by adjusting the position of the nuts on the valve stems for moving the steam valves. When each valve stem has a single nut between lugs on the steam valve the lost motion is reduced by using a thicker nut; or the stroke can be lengthened by increasing the amount of the lost motion—i.e., when there are two nuts and one lug to each steam valve by moving the nuts farther apart and where there is a single nut, the lost motion can be increased by making the nut thinner. Some pumps are provided with valves for regulating the amount of compression in the steam cylinder, thereby obtaining shorter stroke by increasing the compression or lengthening it by decreasing the compression.

Meaning, Use and Determination of "Horsepower Constant"—What is meant by the horsepower constant of an engine and how is it obtained and used?

W. E. T.

In figuring a number of indicator diagrams from one engine running at a constant speed, it is most convenient to compute first the horsepower developed per pound of mean effective pressure. This is called the "horsepower constant" and is to be multiplied by the mean effective pressure of each diagram to find the horsepower represented by that diagram.

As the value of the constant would be the number of horsepower which would be developed by 1 lb. mean effective pressure, therefore, as the usual formula is

$$\frac{\text{pressure} \times \text{area of piston} \times \text{piston speed in feet per min.}}{33{,}000}$$

or $\frac{PLAN}{33{,}000}$ = hp., then the formula for finding the horsepower constant is

$$\frac{1 \times \text{area of piston} \times \text{piston speed in ft. per min.}}{33{,}000} \text{ or,}$$

$$\frac{LAN}{33{,}000} = \text{hp. constant.}$$

Efficiency of Pressure-Reducing Valve—When steam is discharged through a pressure-reducing valve, is there a loss, and if not, what becomes of the heat which the steam may have contained before passing from the higher to the lower pressure?

J. M.

There is no loss in the sense of annihilation. Some of the heat contained in each pound (weight) of steam of the higher pressure passes off by radiation before reaching the valve aperture, and the heat which is employed for work in overcoming friction of the steam in its passage through the valve passes off by radiation or is conserved to the steam at the reduced pressure. But, with good insulation, the efficiency is nearly 100 per cent., for practically all the heat contained per pound of steam delivered to the valve is delivered to the low-pressure side, there to be absorbed by radiation, in raising the temperature or in evaporating water previously condensed, or in sustaining the temperature and pressure of steam on the low-pressure side, and any heat in excess of these demands will be employed as superheat—i.e., the steam at the reduced pressure will be at a higher temperature and will contain more B.t.u. per pound of weight than dry-saturated steam of the same pressure.

Figuring Cost per 1000 lb. of Steam—When the number of pounds of water evaporated per pound of coal from and at 212 deg. F., and the cost of coal per ton are given, what would be the short method of figuring the cost of coal required for evaporation of 1000 lb. of water from and at 212 deg. F.?

H. B.

One thousand divided by pounds of water evaporated per pound of coal would give the number of pounds of coal required for evaporation of 1000 lb. of water. When the cost of coal is quoted per long ton (2240 lb.) then the price per pound would be the cost per ton divided by 2210. Therefore, the cost of the coal required to evaporate 1000 lb. of water would be

$$\frac{1000}{\text{water per lb. coal}} \cdot \frac{\text{cost per ton}}{2240},$$

or,

$$\frac{\text{cost per ton}}{\text{water per lb. coal} \times 2.24}$$

and for 2000 lb. of coal per ton, the cost of the coal to evaporate 1000 lb. of water would be,

$$\frac{\text{cost per ton}}{\text{water per lb. coal} \times 2}$$

Engineers' Study Course

Problems in Power-Plant Design--VII

PIPING LAYOUT

Among the principal points to be realized in laying out a system of power-plant piping are the following: Pipes of ample size to convey the steam from the boilers to the engines without appreciable loss of pressure, reasonable compactness to prevent excessive condensation, the avoidance of pockets, a proper system of drainage to keep all parts of the piping free from water and sufficient flexibility to prevent overstraining due to expansion and contraction. While valves should not be used so freely as to complicate the system, they should be placed in such a manner as to provide all the combinations necessary, and upon all important pieces of apparatus, so that they may be cut out when desired. There are several standard arrangements for power-plant work, that shown in diagram in Figs. 1 and 2 having been chosen for the present problem. The supply system in this case consists of an overhead loop of large size having a connection with each boiler and engine. This is divided into four sections by valves, and provides two paths for the flow of steam from the boilers to the engines. Flexibility is secured by the use of sweep bends, which are clearly indicated in the sectional elevation, Fig. 2. Each boiler connection is provided with two valves to prevent any possibility of steam leaking back into the boilers when shut off for cleaning or repairs.

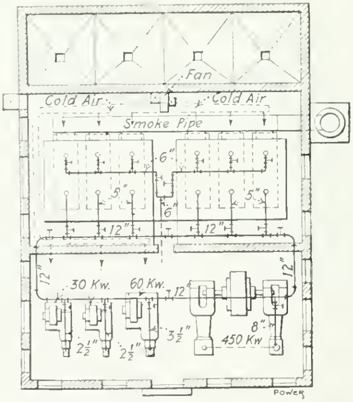


FIG. 1. PLAN VIEW OF PIPING

Large separators are placed in each engine connection close to the throttle valve, and the pipes joining these with the main header are made one size smaller than called for by the engine builders. The object of this aside from drainage and dryness of steam is to have a full supply of steam close to the cylinder in order to provide a cushion on which the blow caused by the cutoff may be spent, thereby preventing vibrations from being transmitted through the piping system; and, finally, to produce a steady and rapid flow of steam in one direction. Here, as in the case of the boiler connections, an extra valve is placed in each lead close to the main. An independent auxiliary header is connected with the front nozzles of the boilers for supplying steam to the various pumps, and to the heating system when live steam is required.

The exhaust piping, steam and water to pumps, heating mains and blowoff piping, are shown in Fig. 3. This drawing is diagrammatic in form and is intended to illustrate the principles involved and the combinations to be obtained.

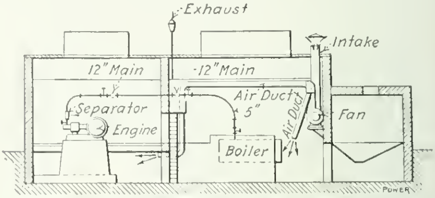


FIG. 2. SECTIONAL ELEVATION OF PLANT, SHOWING ARRANGEMENT OF PIPING

Starting with the exhaust from the main engine, it first passes through an oil separator, then divides into two branches, one leading to the heating system, and one to the condenser, the latter also connecting outboard as indicated. The exhaust from the lighting engines may be turned into the condenser or outboard as desired. The exhaust from the various pumps may pass outboard through a back-pressure valve or may be utilized in a secondary feed-water heater. The main feed-water heater may be supplied with steam either from the heating system or from the main leading to the condenser; connections with both heaters being on the induction principle. As the larger heater will usually be supplied with steam below atmospheric pressure, it must be drained through a return trap having a high-pressure connection. The heating main has a live-steam supply through a reducing valve, and an overflow through a relief or back-pressure valve into the outboard exhaust. A relief valve is also provided between the condenser and outboard main.

By these arrangements the exhaust from the main engine may pass either into the heating system, to the condenser or outboard; and that from the lighting engines either to the condenser or outboard. The live-steam supply to the heating system is entirely separate, and may be used either in connection with the exhaust or independently.

Cooling water for the condenser flows from the outside reservoir to the circulating pump, and is discharged into a special drain leading to the river. A cross-connection is provided for supplying fresh water directly into the receiving tank when required. the reservoir being high enough to produce a gravity flow.

The condensed steam from the air pump may be discharged either into the receiving tank (which is vented to atmosphere) or into the drain above mentioned. During the summer, when the condenser is in continuous operation, the receiving tank will serve as a hotwell from which the boilers are fed.

The connections between the feed pumps and boilers are not shown in the drawing. The main feed line passes through the heaters in series, the larger one coming first. Independent bypasses are provided around each heater so they may be cut out for repairs, or at other times when not in use.

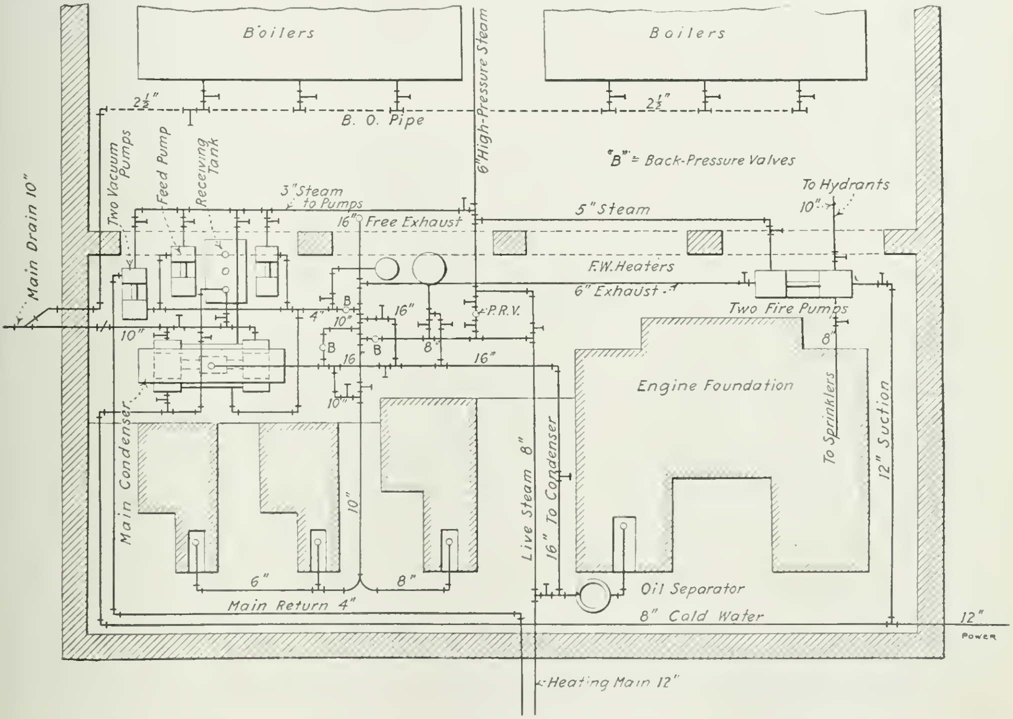


Fig. 3. Exhaust and Heating Piping and Steam and Water Connections to Pumps

The branch to each boiler is furnished with a shutoff and check valve, the former being placed next to the boiler. An injector of sufficient capacity is placed in a bypass of the feed pipe near the boiler fronts for use in case of an accident to both of the pumps. Duplicate vacuum pumps should be furnished, and this is indicated by notes on the drawing, although only one is shown.

All steam separators and mains which are free from oil should be drained through traps to the receiving tank, unless a gravity-return system is installed, which returns the condensation directly to the boilers. Drainage from the oil separator, and all other oily drips, should be discharged into the main drain pipe. The blowoff pipe from each boiler is provided with a special blowoff valve, and is arranged for discharge as shown in the drawing.

The size of steam pipes for power-house work, where the length of run does not exceed 150 to 200 ft., is usually based upon a velocity of flow not exceeding 6000 ft. per min. for supply mains and 4000 ft. for exhaust. To use these velocities it is necessary to reduce the weight of steam at a given pressure passing through the pipe per minute, to cubic feet, which may easily be done by use of a steam table. This volume, divided by the assumed velocity, will give the required area of pipe in square feet. This result multiplied by 144 will give the area in square inches, from which the required diameter of the standard size may be obtained from any table of pipe data and dimensions. A simple rule, which works out well in practice, is to allow 0.12 sq.in. per i.hp. of engine for steam pipes, and 0.18 sq.in. for exhaust pipes. This applies to modern engines of good economy and is on the side of safety. The factor 0.12 may also be used with good results for proportioning the boiler connections, because 30 lb. of steam per hr. at 70 lb. pressure represents the average water rate of a simple noncondensing engine, as well as the quantity furnished by one boiler-horsepower.

Applying the above to the boilers in our model plant gives

$$120 \times 0.12 = 14.4 \text{ sq.in.}$$

which comes between the areas of a 4- and a 5-in. pipe, and the larger size has been used for the leads between the boilers and main.

The size of piping is also fixed to a considerable extent by the outlets left by the makers upon engines and other pieces of apparatus. When this method is employed, and several branches are joined into a single main, an equation of pipes is made use of, and for convenience in design a table of this kind covering the sizes used in ordinary power work is given in Table 1.

TABLE 1—AN EQUATION OF PIPES

Dia. in.	2	3	4	5	6	7	8	9	10	12	14	16	18	20
2	1													
3	3	1												
4	5	2	1											
5	10	3	2	1										
6	15	5	3	1.5	1									
7	23	8	4	2	1.5	1								
8	32	11	5	3	2	1.5	1							
9	43	15	7	4	3	2	1.3	1						
10	56	20	10	5.5	3.5	2.5	1.7	1.3	1					
12	71	32	15	9	5.5	4	2.8	2	1.6	1				
14	130	47	23	13	8	5.5	4	3	2.3	1.5	1			
16	181	65	32	18	11.5	8	5.7	4.2	3.2	2	1.4	1		
18	243	88	43	24	15	10.5	7.6	5.7	4.3	2.8	2	1.3	1	
20	316	115	56	32	20	14	10	7.4	5.7	3.6	2.4	1.7	1.3	1

For example, the carrying capacity of a 10-in. pipe is equivalent to ten 4-in. pipes, 5½ five-inch pipes, and 1.3 nine-inch pipes, etc.

When a fractional number of pipes is involved, the change to a whole number should be on the side of safety. For example, a 14-in. pipe is equivalent to 2.3 ten-inch pipes, and it would, therefore, be safe to join two 10-in. branches into a 14-in. main. On the other hand, a 16-in. pipe is equivalent to only 5.7 eight-inch pipes, but the difference is so small that it would be safe to join six into a 16-in. pipe for lengths of run less than 100 ft.

When steam is to be carried long distances, as in supplying a group of buildings from a central plant, Tables 2, 3 and 4 may be made use of. They are abridged from similar tables published by the writer in POWER, September, 1908.

Table 2 gives the pounds of steam discharged per minute through pipes of different diameters, 100 ft. in length, for drops in pressure of ¼, ½, 1 and 2 lb. between the two ends of the pipe.

TABLE 2—FLOW OF STEAM THROUGH PIPES IN POUNDS PER MINUTE

Dia. of Pipe, In.	Drop in Pressure ¼ Lb.	½ Lb.	1 Lb.	2 Lb.
3	8.6	12.3	17.6	25.4
4	18	26	37	53
5	32	46	66	95
6	52	73	106	152
7	77	109	157	226
8	108	154	222	319
9	147	209	300	432
10	192	273	393	567
12	305	434	623	900
15	535	761	1090	1580

These values are for initial pressures below 2 lb. For higher initial pressure, multiply the quantities given in Table 2 by the factors in Table 3.

TABLE 3—FACTORS FOR INITIAL PRESSURE OF 10 TO 100 LB.

Drop in Pressure, Lb.	Initial Pressure, Lb. 10	30	60	100
¼	1.27	1.68	2.13	2.60
½	1.26	1.66	2.11	2.58
1	1.24	1.64	2.08	2.53
2	1.21	1.59	2.02	2.47

For lengths of run other than 100 ft. multiply the quantities in Table 2 by the factors in Table 4.

TABLE 4—FACTORS FOR LENGTH OF RUNS OTHER THAN 100 FT.

Length of Run, Ft.	Factor
20	2.2
50	1.4
100	1.0
200	0.7
300	0.6
400	0.5
600	0.4
800	0.35
1000	0.31

EXAMPLE—What sized main will be required to deliver 130 lb. of steam per min. a distance of 400 ft., with an initial pressure of 100 lb. per sq.in. and a drop in pressure of ¼ lb.?

From Table 3 the factor for 100 lb. initial pressure and ¼-lb. drop is 2.6, and from Table 4 the factor for 400-ft. run is 0.5. Therefore, the quantity to look for in Table 2, under ¼-lb. drop, is

$$\frac{130}{2.6 \times 0.5} = 100$$

which corresponds closely to the 108-lb. capacity of an 8-in. pipe.

WEIGHT OF PIPE, FITTINGS AND VALVES

Standard-weight steel or wrought-iron pipe is considered sufficiently strong for the pressures ordinarily carried in power-plant work. Although guaranteed for only 125 lb. per sq.in., tests show it to be amply safe for pressures somewhat higher. In the present case, where the working pressure is to be from 120 to 130 lb. it can be safely used.

Cast-iron fittings are commonly made in three weights: light, for exhaust and condenser piping; standard, for pressures up to 125 lb., and extra heavy, for higher pressures up to 250 lb. All feed piping around pumps and boilers should be of brass, iron-pipe size, made up with standard brass fittings. In general, gate valves are best for high-pressure work, and for the larger sizes, say 4 in. and above. The outside screw or yoke pattern is to be preferred.

For sizes 8 in. and above, the bypass type should be employed on account of greater ease in operation, and less liability of scoring the seat when opening and closing.

VENTILATION

The method of ventilating the boiler room is shown in Figs. 1 and 2. A sufficient volume of air is supplied to change the contents of the room four times an hour. The fan is mounted upon the wall in front of the coal bunker, and takes its supply through an intake carried above the roof. Air is delivered in front of each boiler through a downtake pipe, and to the space beneath the engine room occupied by the pumps and condenser. Discharge ventilation is through the monitor. The engine room is ventilated entirely by means of windows and monitor.

⁂

First American Boiler Steel—At the recent meeting of the American Boiler Manufacturers Association, it was brought out that the first steel used for boiler purposes in the United States was made by Hussey, Wells & Co., by the crucible process, and put into a mud drum on the boilers of the steamer "Tom Reese" in 1868.

⁂

Water-Power Surveys in Snake River Basin—Topographic engineers of the United States Geological Survey have been making profile surveys in the Snake River basin, Idaho—surveys, incidental to their general topographic mapping—and the results of their work have just been published by the survey in Water-Supply Paper 347, which also contains a map of the area examined.

The Snake River basin has many good storage sites, but only a few have been utilized. About 400,000 acre-feet of water can be stored in Jackson Lake by a dam which has been constructed by the Reclamation Service. The largest site is at Swan Valley, on Snake River, where the water available for storage is approximately 4,000,000 acre-feet. Irrigation has reached a high stage of development in the Snake River valley, yet approximately 6,000,000 acre-feet of water annually runs to waste. Eventually these flood waters will be stored and used to irrigate thousands of acres of arid land. The streams afford enormous water powers, but only a few sites have been developed owing to the lack of market.

A copy of the water-supply paper may be obtained free on application to the Director of the United States Geological Survey, Washington, D. C.

A Practical Method of Determining the Fatigue Limit of Metals*

SYNOPSIS—When a piece of steel is stretched it cools until the elastic limit is reached; if the stretching is continued beyond this point, the temperature rises. The author turns a groove in a circular specimen, holds it as in a lathe chuck and hangs a weight upon the extended rod at some distance from the groove. The specimen bends at the circular nick, the top being put into extension and cooling, the bottom into compression and heating. When the specimen is revolved, the heating offsets the cooling and the temperature remains constant until the load applied becomes so great that the limit of elasticity or fatigue limit is exceeded when the temperature commences to rise. By observing the time such heating begins, the fatigue limit can be thus quickly determined.

⁂

One of the most novel and interesting, and possibly the most important, steps in the determination of the properties of materials by means of physical tests, has been proposed and practically demonstrated by C. E. Strohmeyer, chief engineer of the Manchester Steam Users Association.

Mr. Strohmeyer has apparently solved the problem of making the determination of the fatigue limit of materials practical. Woehler, who was the chief engineer of a Prussian railway, made an extended series of tests to determine the fatigue limit of steel, the results of which were published in 1871; these tests were made in an investigation of the behavior of car axles and springs. In Woehler's tests, some of the samples were stressed many times, a few being vibrated upward of 50,000,000 times without any assurance that they would ever break. On account of the length of time involved, few experimenters have attempted to duplicate Woehler's experiments, since a test of the length indicated above required about one and one-half years continuous running.

The difficulty about the practical use of the results of Woehler's tests and those that have been made later, was that no satisfactory correlation could be established between the results of the different tests. As a makeshift it was proposed to make several fatigue tests of a material arranged so that the amount of stress that would break the sample when applied about 1,000,000 times could be determined approximately. Dr. Martens, of Berlin, in order to overcome the difficulty, has recently adopted as a standard of comparison the number of times that a stress of 19 tons per square inch can be repeated before fracture occurs.

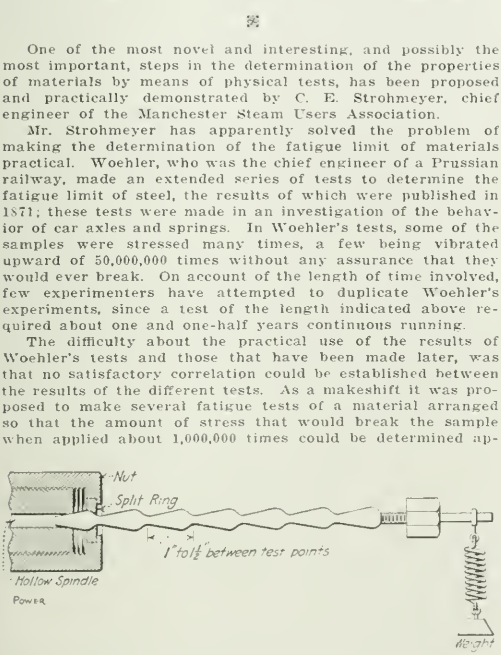


Fig. 1. Mode of Testing

Mr. Strohmeyer reasoned that the lack of harmony among fatigue limit tests might be due to irregularity in the fatigue-resisting properties of the different samples tested. To insure uniformity so far as possible, he arranged his samples for bending tests as shown in Fig. 1, the different test points on each specimen being arranged so that they were only 1 to 1½ in. apart, and therefore six tests could be secured of a sample in a length of 6 to 9 in.

Owing to the uniformity secured by means of the shortness of the sample, the results of Mr. Strohmeyer's tests could be harmonized, and by comparing his test results he found that the following formula applied

$$N = \frac{10^6 C^4}{(Sn - Fl)^4} \qquad (1)$$

in which N equals the number of repetitions of the stress Sn: Sn being the nominal test stress applied to the specimen, Fl the fatigue limit of the material under test and C a constant for the particular sample under test. This formula can also be written

$$Sn = Fl + C\left(\frac{10^6}{N}\right)^{\frac{1}{4}} \qquad (2)$$

and Sn may be K, according to whether the stress is tensile or compressive.

It can be seen from inspection that, if formula (2) is true, a determination of the number of vibrations required to fracture a sample under two widely varying stresses representing Sn would give a knowledge of all the intermediate values and also of the fatigue limit Fl. For example, if, as in Fig. 2, a sample which is stressed to 25 tons failed at 5000 applications of this load, and when stressed to only 13 tons failed at 1,000,000 applications, all other values representing the number of applications at which this sample would be supposed to fail when subjected to any other stress would lie on the straight line joining these two points, since the verticals representing the number of applications are arranged at such distances from the "y" axis as to represent the fourth root of the reciprocal of the number of applications. When the results of the tests made on the close-spaced specimens, as illustrated in Fig. 1, were plotted, it was found that they did lie on practically straight lines.

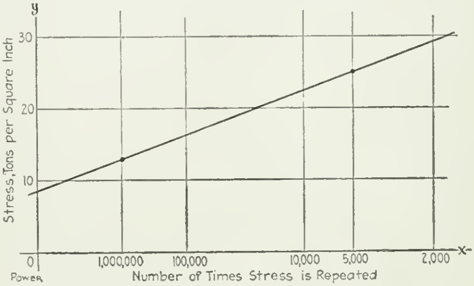


Fig. 2. Record of Tests

In making these tests it was found necessary, in order to secure accuracy, to run one sample at such a stress that it would fail at about 1,000,000 repetitions of the load, and on account of the length of time involved, even assuming that the formula was correct and that the fatigue limit could be obtained from the extrapolation of the values found, this means of obtaining the fatigue limit could not be considered entirely practical for use in the regular testing of materials.

Happily, a short method of directly determining the fatigue limit of a material occurred to Mr. Strohmeyer while making these tests. This method was based on the principle that within the elastic limit there is practically no internal friction with elastic material, such as steel, but that as soon as the elastic limit is reached the molecular friction is set up and is manifested by the production of heat. If some means could be devised to detect the first signs of a temperature rise in a specimen under test, Mr. Strohmeyer reasoned that the stress applied at that instant would represent the fatigue limit or the true elastic limit of the material under test.

Acting on this idea, some samples were tested, which were surrounded by a loose-fitting sleeve of rubber. Water was passed in the space between the tube and sample while the test was in progress and the temperatures of the water at the inlet and outlet were taken.

When a difference of one degree Centigrade was noted, the fatigue limit was supposed to have been reached and it was found that the fatigue limits indicated in this way were very clearly defined.

What was considered of much more importance than the good definition of the fatigue limit, was that the fatigue limits arrived at by this means agreed remarkably well with those as found by extrapolation of the series of tests carried to the point of failure. The reason of the importance of this agreement is that it indicates that the formula as stated above applies to an infinite number of applied stresses as well as between the limits through which it was derived.

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*An abstract of the memorandum of the chief engineer of the Manchester Steam Users Association for 1913, issued June, 1914.

With this means of determining the fatigue limit of materials available, it is only necessary to start to test a sample and gradually increase the stress applied until the fatigue limit is reached and then to increase the stress at once to such a point that failure will occur after a few thousand applications.

By noting the number of applications required to break the specimen at this high stress and the application of the formula given above, all the intermediate values may be obtained. Torsional fatigue tests were made on the same principle and the fatigue limits determined in the same manner.

In comparing the fatigue limits of several sets of these torsional tests where a number of tests had been made on each sample, it was discovered that the agreement between the fatigue limits, as found for such samples, were equally as good as the agreement between the tensile strengths found by testing a number of samples cut from a plate, side by side.

The agreement was also as good as that found for the tensile strength of forty-one steel bars as tested by Dr. Martens, who tested this number, of five-foot lengths, by taking a sample from each end and two from the middle. It was hoped by Mr. Strohmeyer that fatigue limit determinations under tensile stress would furnish results in still closer agreement, a machine being in process of construction which would permit tests of this character being made. To illustrate how this method of testing and the formula derived may be a very practical aid in selecting the best material for a given purpose, two examples from the many tests made were selected. The first specimen of steel selected was found to have a fatigue limit of 12.60 tons per square inch and the value of constant C was found to be 0.504, or the formula giving the number of vibrations to failure would be

$$N = \frac{10^6 \times 0\ 504}{(Sn - 12.60)^4}$$

The other sample selected showed a fatigue limit of 11.10 tons per square inch and a constant C of 2.42. If the duty expected of a material was such that no shock was to be experienced that would stress the metal beyond its true elastic limit or its fatigue limit, the first material with the highest fatigue limit would be selected.

If, however, the nature of the work was such that the elastic limit must be exceeded, the material with the highest coefficient C would be selected. As will be seen by assuming a working stress Sn of sixteen tons per square inch, the first sample given above would be expected to stand only 480 repetitions, while the second should be able to resist about 60,000 applications of such a stress before failure would result. The time involved in making a complete fatigue limit test of a sample by Mr. Strohmeyer's method is only one to two hours, which places such tests on a basis that will permit their practical use. The author states that before recommending the fatigue test for the practical determination of the suitability of a material for any particular purpose, the work of correlating the results of such tests with practical experience in failures will have to be completed. Work of this character has already been started in the investigation of a number of failures of copper pipes, which failed on account of the movement of the engines to which they were attached.

*

Electricity in the Anthracite Industry—The introduction of electricity in any great quantity into the mines is not more than two decades old. The first electrical installation was made in 1887 by the Pennsylvania R.R. In 1889 the Thompson-Houston Co. installed a locomotive and a generating station in the Erie Colliery of the Hillside Coal & Iron Co. and this locomotive was in continuous service until 1911. The first electric pump was installed in 1890, and it has been in continuous operation ever since.

The present total capacity of supply purchased or generated is 105,400 hp. compared with 440,300 hp. produced by steam for direct use. Today there are 169 miles of wooden pole lines above ground and 754 miles of trolley wire below ground in the anthracite mines. There are 951 electric locomotives using an estimated amount of over 60,000 hp. The other electrically operated equipment requires 19,170 hp. for breakers and miscellaneous machinery, 23,280 hp. for electric hoists, 38,500 for electrically driven pumps, 2920 for coal-cutting machines, 3650 for lighting and about 100 for heating. There are now five breakers equipped with individual motor drives, and others are under course of construction.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

See that the Maxim silencer has taken root in our field. We need a noise trap for more than one kind of "sound wave" in our midst. Hope, though, it does not clap the muffler on our old-time friend, What-Caused-the-Knock.

*

The New York "Sun" sure has a grim sense of humor. Read this:

> The executioner at Charlestown, Mass., state's prison has notified the warden that on account of hard times he will reduce his price for electrocuting condemned prisoners. It is believed he is not seeking to stimulate business, but rather to preclude his substitution by a cheaper man.

And this item is printed under the heading "Sunbeams"!

*

The first chairman of one of the first of the public service commissions seven years ago made this prophetic pronouncement: "The public will ultimately have what it wants. If it has set up machinery which does not produce the results it desires, that machinery will surely be relegated to the junk heap and a new installation made."

One big reason for creating this type of commission was to secure relief from unjust treatment by the powerful public service companies. Looks like old man Public will have to wake up and exercise his prerogatives.

*

Here's a new use for a barometer, as set forth by the "Chicago Herald:"

> A bricklayer lay ill, and the doctor, having done what he could, told the man's wife to take his temperature in the morning. Calling the next day, the doctor asked if his instructions had been followed.
>
> "Well, we hadn't a 'tremometer,'" the good woman replied, "but I put a barometer on his chest and it went up to 'very dry.' So I gave him a bottle of beer and he's gone to work."

*

When it comes to a "get together," the alert engineer is some swarmer! Electrical, mechanical and civil, they gathered in Boston recently to hear Brother Waite tell how, as city manager of Dayton, Ohio, that city of 125,000 men, ladies and kids is taken care of on a strictly business basis. "Exit the Politician—Enter the Engineer" is the title of one of this week's editorials. The news story is on page 795. Read 'em both! They are most digestible food for thought, so take a big mental bite out of each.

*

Lives of engineers remind us
That their lives can't be sublime
While they're poked down in a basement,
Working seven days at a time!

*

A lady fireman has been forbidden to operate a New York schoolhouse boiler, though she has a police department license to run any boiler not over 90 lb. pressure. The board of education has put on the kibosh. Is this one more reason why the power to grant licenses should be taken away from the cops?

*

Of course you were pleased with the "National Engineer's" reproduction of the engrossed resolutions of appreciation the N. A. S. E. presented the Allis-Chalmers folks for courtesies extended during the Milwaukee convention. It was a fine touch of appreciation.

*

The Milwaukee Efficiency Society recently listened to a lecture on "The Human Eye and Protective Measures for Keeping It in Working Condition." They sure gave good measure with all the eye-openers we glimpsed during our recent brief visit to that charming city while under the care of Drs. Wickert, Peterson and Mistele.

*

"The policy of home rule of utilities—that is to say, local instead of state regulation of privately owned plants—proved to be in several cases only a frankly admitted disguise to cover a real policy of public ownership and operation," remarks the "Electrical World" of the recent Mayors' Conference in Philadelphia. Let's wait and see what is the outcome of the Utilities Bureau. Mebbe New York City could have decided the Edison rate case long ago if this growing little village did not have to appeal to those state-appointed, fifteen-thousand-dollar Public Service fellers.

City Management and the Engineering Profession

A large attendance of engineers representing all branches of the profession gathered at Chipman Hall, Boston, on Nov. 18, to hear an address by Henry M. Waite, city manager of Dayton, Ohio, upon "The City Manager Plan and Its Relation to the Engineering Profession." The meeting was under the auspices of the Boston Society of Civil Engineers and the Boston sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. Mr. Waite discussed the city charter of Dayton at length, pointing out the efficiencies in municipal administration secured under the commission-manager plan, which in 11 months' trial at Dayton has appeared to completely realize the divorce of municipal administration from politics and the concentration of responsibility for all public business, long seen by acute observers to be one of the most desirable attainments to be secured in American life.

On the engineering side, the speaker touched upon the benefits of financing and administering water-works and sewer systems on a purely business basis, paying as the city goes, and he pointed out that most of the great problems of the modern city are of an engineering nature. The publicity of the city-manager plan is one of its strongest features. In conclusion, the speaker urged engineers entering this field to cultivate the power of presenting cases on their feet to public boards, stating that inability to speak is a serious handicap to personal efficiency. Former Mayor James Logan, of Worcester, Mass., also addressed the meeting upon the importance of devotion to civic responsibilities by the engineer.

Chicago Section A. S. M. E. Meets in La Salle Hotel

On Friday evening, Nov. 20, the Chicago section of the American Society of Mechanical Engineers held its first meeting of the season in the Louis XVI Room of the La Salle Hotel. The meeting was of the informal dinner variety so popular last season. Fully 140 sat at table. Promptly at 8 o'clock Chairman S. G. Neiler opened the meeting with a few words of thanks to last year's committee for suggestions and assistance in getting things under way.

WINSLOW HIGH-PRESSURE BOILER

W. H. Winslow, the first speaker, aroused a great deal of interest as he explained the construction and operation of his new high-pressure boiler. He dwelt briefly on what had been done in the way of experimental work during the last four years and of the fields to which the boiler would be applied. Mr. Winslow touched upon the possibilities of high pressures and of the Stumpf una-flow engine, which appears to be the prime mover best adapted for high pressure and superheat. Naturally much of the talk, which was thoroughly illustrated with lantern slides, was along the same lines as the article on other pages of this issue describing the boiler, so that repetition here will be unnecessary.

Henry A. Allen, consulting engineer for the City of Chicago, was scheduled to lead the discussion. He referred briefly to the old rectangular marine boiler carrying 20 lb. pressure, the Herreshoff boiler of later date and a modern boiler in a water-works plant under 220 lb. pressure. It was his belief that the new boiler was specially adapted for portable use, such as for the automobile truck or bus and the large tractor plow. In either service, steam had the advantage over the internal combustion engine. With its multiplicity of parts, the Winslow boiler had all the advantages of the Herreshoff in portable work. This construction eases up on the work of regulating the feed pump. The small flexible tubes to the steam header were to be commended for work where vibration could be expected. It was his final conclusion that for different lines of work, boilers must be specially designed, the portable field requiring different construction than a boiler for stationary use. In the latter it was an advantage to have a considerable quantity of water in circulation. The present boiler possessed novel features, having many good points for different kinds of work. With its small tubes it belonged to the safe type and possessed the advantage of flexibility. The final test, however, was use, and he wished Mr. Winslow every success, as better portable outfits were badly needed.

Robert Cramer, engineer of the Winslow company, was more optimistic on the possibilities of the boiler than his predecessor. While believing that it was the best portable boiler, it was his conviction that the Winslow boiler would find its way into the largest power plants and would show results at least 12 per cent higher than the best obtainable today. The cleaning facilities could be easily improved and other difficulties would be met as they come to them. A few sections in reserve instead of entire units was an important point. The boiler consisted of parts of small bulk and weight which could be taken through small areas, and the boiler built up in place. For marine use they could get in a given space larger boiler capacity than was possible with any other type. Four years had been spent in developing the boiler to a point where they at least were satisfied that it was better than anything else offered for the purpose heretofore.

BOILER EFFICIENCY METERS AND EUROPEAN BOILER PRACTICE

W. A. Blonck, maker of the boiler efficiency meter, introduced his remarks of the evening by a vivid account of his experiences in Europe, from which he had just returned. Briefly he explained the principles of his meter, with the red and blue fluids showing the drop in draft through the furnace and the setting, respectively. His new recording meter was flashed upon the screen with a number of other slides, and charts made up from the records of his instruments were shown. It was with considerable pride that he displayed a certificate of merit from the Franklin Institute, granted after an investigation by the committee on science and arts, on the novelty of his work in establishing the zero point for the efficiency meter.

In the latter part of his talk, Mr. Blonck turned to European boiler practice. By means of slides he showed the fine architectural design of the buildings and the efforts made to add to the appearance of the stack. Cross-sectional views showed the unit design generally followed and the small bunker capacity for coal. The latter was stored on the ground and conveyed to the boiler as needed. The injector draft chimney was in frequent evidence and ash-handling facilities were a negative quantity, due largely to cheap labor. Small steam pipes with velocities up to 14,000 ft. per min. were also a feature.

Much of the latter part of the talk centered around the high-duty boiler with built-in economizer. The gases made a single pass through the heating surface to an economizer having nearly as much surface as the boiler. Diagrams were presented to show the difference in temperature between the gases and the water in the type under discussion and in the normal boiler with independent economizer. For the high-duty boiler a greater difference was apparent, indicating better heat absorption. In each case the exit temperature of the gases was about the same.

Evaporation tests and heat balances of a high-duty boiler at Hamburg were presented. The boiler contained 3700 sq.ft. of heating surface, 1050 sq.ft. of superheating surface, 3110 sq.ft. of economizer surface and 149.5 sq.ft. of grate surface. The ratios of heating to other surfaces in their respective order are 3.52, 1.19 and 24.8. The grate has double the area that would obtain in standard practice in this country. Fuel beds are only 3 or 4 in. thick and require an immense amount of attendance. At normal load an evaporation f. and a. 212 deg. of 10.24 lb. of water per pound of coal as fired was obtained. The efficiency of the boiler was 70.6 per cent.; of boiler and superheater, 77.3 per cent., and of the total installation 86.3 per cent. The coal had a heat value of 13,650 B.t.u. The loss in the flue gases was 10.5 per cent. and in radiation 3.2 per cent. The temperature difference between the outgoing gases and the water in the economizer was about 130 deg.

In the discussion, Joseph Harrington thought that the German boiler, due to its arrangement, had the advantage of economy in floor space. The individual "megaphone" stacks did not look pretty, but there was one for each boiler, so that the area was always in proportion to the boiler it served. Too much area frequently found in a stack designed for present and future installations was almost as bad as too little. The criterion of overall efficiency was the amount of waste heat going up the stack. In the test figures given this was found to be exceptionally low. The large grate surface, 100 per cent. excess air and 10 per cent. CO_2, were out of harmony with our ideas. As to the Blonck meter, it was all right. It was just as accurate an instrument as any ever built, and, if rightly interpreted, should be of great value in the boiler room

MECHANICAL FILTERS

Walter H Green, chief engineer of the International Filter Co., talked on mechanical filters, dwelling on methods of rating and some of the experiences his company had had with prospective customers. He explained that a mechanical sand filter was more rapid because a coagulant was used, but that there was a limiting rate at which a filter could be properly worked. Reference was made to the tendency of installing filters that were too small. In some cases the filter had to be bypassed, as the necessary amount of water could not be forced through. It was a question whether to use sand or quartz. Either will work, as both are practically the same thing, except that the sand is used in its natural state and the quartz must be ground. There was a difference in sand, however, and some discretion was required in making a proper selection. Sand with grains of uniform size was desirable, and if this was obtained, it gave better results than quartz, as, due to the mechanical grinding, uniformity in the size of the particles could not be expected.

Clinkering Properties of Coal

At a joint meeting of the Philadelphia Engineers Club and the local branch of the A. S. M. E., on Saturday evening, Nov. 21, F. C. Hubley, assistant engineer of tests of the American Bridge Co., read an instructive paper on the clinkering of bituminous coals.

As the speaker pointed out, coal is now commonly purchased on specifications, based on analyses and a B.t.u. determination. This information, while desirable, is not conclusive as to the probable behavior of the coal; therefore, it should be accompanied by a knowledge of the clinkering properties and the fusing temperature of the ash. The latter is more or less indeterminate and is not as important as the fusing range, represented by the temperatures between which the ash starts to soften and runs freely. Experience has shown that a long-range, slow-fusing ash produces a troublesome gummy clinker, whereas one having a short-range forms a porous clinker which can easily be broken up. In view of this, one should select a coal having a short range, the upper limit of which is well above the maximum temperature likely to occur in the furnace in which it will be used.

Mr. Hubley described two methods of predetermining the fusing range which have been employed by the American Bridge Co. The first of these was the "cone" method which owing to the time required, has now been superseded by the "fusiometer," an instrument for recording the softening of the ash with corresponding rises in temperature.

CONE METHOD

A sample of the coal is first ground to pass through a 50-mesh screen and is then burned to ash at a dull red heat. The ash is next mixed with water to form a paste which is placed in a hard-wood, cone-shaped mold; glazed paper between the ash and the mold prevents sticking. It is then baked at about 250 deg. until the ash forms a solid cone, upon which it is removed from the mold and placed in a gas furnace for three minutes. The temperature of the furnace is under control and is measured by a thermo-couple. By subjecting a number of cones to different temperatures and noting the relative deformations, the fusing range can be arrived at and a curve plotted. The color of the cone is also an indication of its fusibility, a light brown accompanying little or no deformation and a dark brown or purple denoting complete softening of the cone.

FUSIOMETER

In this case the dry ash is prepared as before and then compressed under a pressure of 25,000 lb. per sq.in. into a pellet, ⅝ in. diameter and ½ in. high.

The fusiometer consists essentially of a frame carrying a small gas-fired furnace into which project two carbons set on a common axis. Between the carbons is placed the ash pellet under a pressure of 1½ lb. The upper carbon is free to move up and down and is attached to a pointer which magnifies twelve times on a scale any expansion or contraction of the pellet. The temperature of the furnace is measured by a thermo-couple. Thus by subjecting the pellet to gradual increases of temperature, the corresponding expansion or contraction can be noted and the fusing range determined from the curve plotted.

At first the carbons will expand, but later the pellet will soften and decrease in thickness until it finally collapses. In these fusiometer determinations the fusing temperature has been chosen arbitrarily as the point at which the pellet has settled to half its original height; at this point the ash begins to flow. A furnace temperature of 2700 deg. F. may be attained with illuminating gas and over 3000 deg. with blau gas.

In commenting upon the composition of the ash as affecting the fusing qualities, Mr. Hubley said it had been the experience of this company that iron oxide and calcium sulphate tended to produce low-fusing temperatures. Of the constituents of ash, aluminum appears to be the most infusible, fusing at about 3200 deg.; silica comes next, fusing at about 2900 deg.; and the other elements may be regarded as fluxes of which iron is the most potent. In his opinion sulphur did not follow any rule, although when combined with iron in the form of pyrite it invariably produced a low-fusing temperature.

The fusing temperature to be specified in the purchase of coal will depend on the load conditions. Where the boilers are forced, a high furnace temperature will be had, in which case with Pennsylvania coal the speaker recommended 2600 to 2700 deg. Of course for lower rates of driving and different coals somewhat lower temperatures should be specified.

PERSONALS

Prof. L. H. Harris, formerly professor of electrical engineering in the University of Pittsburgh, has been appointed consulting engineer to the Public Service Commission of Pennsylvania. In conjunction with Prof. R. H. Fernald he has just completed the commission's first important publication, a booklet on service rules and regulations pertaining to electricity, gas and heat.

ENGINEERING AFFAIRS

The Detroit Engineering Society schedules the following meetings:

Dec. 4. M. Luckiesh, of the Nela Research Laboratory, Cleveland, Ohio, "Importance of Direction, Quality and Distribution of Light."

Dec. 18. Dean M. C. Cooley, department of engineering, University of Michigan, "Engineering in a Broader Aspect."

Jan. 8, 1915. E. T. Howson, engineering editor, "Railway Age Gazette," Chicago, "Heavy Construction Work in Railroad Building."

Jan. 22, 1915. Prof. H. S. Sadler, University of Michigan, "Gleanings from the University of Michigan Naval Tank."

Brooklyn Combined Engineers—The seventh annual entertainment and reception of the Combined Associations of Engineers of the Borough of Brooklyn, N. Y., was held on Saturday evening, Nov. 21, at Kismet Temple, Brooklyn, N. Y. The entertainment program, consisting of four vaudeville numbers and a minstrel show by the N. A. S. E. "Bunch," was greatly enjoyed by the large attendance, which included many prominent engineers and representatives from the various supply houses. Dancing concluded the night's fun. A. F. Theirgard was the floor manager. Brooklyn Associations Nos. 8, 27, 41, 57, Melville Council No. 9, of the Universal Craftsmen and the Modern Science Club, comprise the Combined Associations of Brooklyn.

BUSINESS ITEMS

Floyd F. Woods has been appointed sales manager for the Epping-Carpenter Pump Co., of Pittsburgh, Penn., taking the place of R. Bowen, who is no longer connected with the company.

The Mountain Ice Co. is putting a 219 kv.-a. Terry turbo-alternator set in its plant at Gouldsboro, Penn., and the Excelsior Needle Co., which is adding a new three-story building to the plant at Torrington, Conn., is installing a 375 kv.-a. Terry turbo-alternator set.

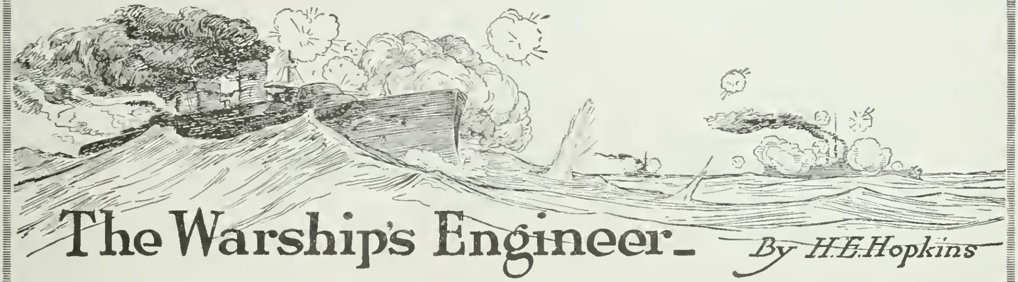
Gifford-Wood Co., Hudson, N. Y., is issuing a booklet containing a valuable article on the Basin Saw and its value to the ice harvester, by Frank H. Abbey. It is a well illustrated educational article and is sent free to anyone interested in ice and harvesting of ice.

Warren Webster & Co., Camden, N. J., has just issued a 64-page book which should interest every power-plant man. The title is "Heating the Manufacturing Plant by the Webster System." It illustrates plant after plant in which the Webster Vacuum System of Steam Heating is used, and gives in industrially classified form the names of a large number of concerns which have adopted it. Copies of the book are sent on request.

The Brown Instrument Co., of Philadelphia, has just moved into its new shops at Wayne Junction, where it has increased and improved facilities for the manufacture of its instruments of precision, such as pyrometers, voltmeters, ammeters, etc. It is most interesting to see how modern machine-shop methods and development have been applied to this line of work, which requires the maintenance of delicate standards and the preservation of cleanliness and accuracy, and visitors are always welcome.

POWER

Vol. 40 NEW YORK, DECEMBER 8, 1914 No. 23

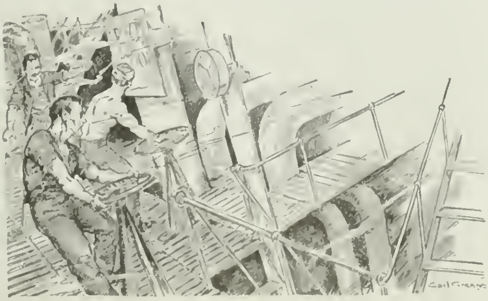


The Warship's Engineer

By H. E. Hopkins

WHO is it in dread war's fell strife
That looms so large in death, in life,
As he whose post is far below,
'Midst hissing steam and furnace glow?
The warship's engineer.

Who is it calm and steady stands
And works where Duty's stern demands
Make him a helpless victim there
That those on deck may do their share?
The warship's engineer.



Who is it when the stricken craft
Is dealt a blow that, fore and aft,
Upheaves and rends her, marks her doom—
Who "stands by" in the engine room?
The warship's engineer.

Who is it when the tale is told
Of brave deeds done by sailors bold
Has "gone down with his ship" to save
His fellows from a deep-sea grave?
The warship's engineer.

Who is it in dread war's fell strife
Should get from us in peaceful life
Due meed for work that WE well know?
On whom shall we our praise bestow?
The warship's engineer.

Equipment and Methods in Largest Refrigeration System--I

By Charles H. Bromley

SYNOPSIS—Describing the design and operation of equipment in the Sargent's Wharf station of the Quincy Market Cold Storage & Warehouse Co., Boston, Mass. The company has a total rated capacity of 4000 tons daily, the station having a 1000-ton compressor, the largest ever built and embodying most interesting features of design. The system is in two parts, a warehouse system having seventeen large houses and a street system having six miles of piping and supplying 800 separate services. In hot weather as much as 50,000,000 gal. of brine is circulated daily. Every possible precaution is taken to insure continuous service the year around, for service interruptions here are as much to be feared as those in electric central-station and in railway practice.

◆

Introductory

Millions of dollars is a lot of money. When invested in perishable foodstuffs, the market value of which fluctuates, and supplying the most densely populated section of this continent, the problem of preserving these products is one of great economic and engineering importance. We will consider only the engineering part of the problem.

Right here, the writer wishes the reader to understand that in this plant uninterrupted service is paramount. To shut down is unthinkable.

Service is sold on a guarantee that the temperature will not vary more than one degree. Suppose the plant fails only for a short time in summer; then the temperature rises and hundreds of thousands of dollars' worth of produce may be ruined. The dealer can claim damages for his loss, and there is always the possibility that, should the service fail and the temperature rise considerably at a time when the market value of the produce is going down, with every indication that it will not rise soon, the dealer might sue, claiming injury to his produce, and thus try to recover a loss or avoid an impending one. Where over 800 customers are served on the street system alone and seventeen large warehouses are filled with perishable goods, the damages due to service interruptions would be large.

Service interruptions are as much to be feared as in electric central-station or railway practice, either of which can drop its load and pick it up where it dropped it. A refrigeration station cannot do this. The moment service ceases, the temperature begins to increase, and by the time the plant is again in service, the temperature may have risen so high as not only to damage the goods, but—and here is the point—to require hours to get it back to normal.

Differing from electric or railway station practice, the load is practically constant 24 hours a day for whole seasons. From the viewpoint of overall station economy, this may be desirable, but where real estate values are high and the station's capacity is none too great for the maximum demand, the equipment must go into service prepared for a nonstop run of months. Every feature of operation, every detail of design must be planned to this end, and should an accident occur, the exigencies demand that the crew be capable of getting the machine back into service with the least possible delay, which means that it must be, to a great degree, independent of outside aid except for very exceptional cases.

All this is mentioned because features of design and peculiarities of practice will be considered that may, without having in mind the nature of the service, be thought extreme and unjustified.

The Sargent's Wharf Station

As you take the old South Ferry for East Boston, at the foot of Eastern Ave., you see little to indicate that, at the rear of the great warehouse on Atlantic and Eastern Aves., is the "heart" that keeps alive the greatest of refrigeration systems. It is there, however, and embodies many of the most interesting things in power-plant practice that the writer has ever seen.

This plant has a total refrigeration capacity of 2200 tons daily in three machines, a 400-ton, an 800- and one 1000-ton; the last is the largest refrigeration unit ever built. It was designed by and constructed under the supervision of the Quincy Market Co.'s engineer, F. L. Fairbanks. This machine is shown in Fig. 1 and will be described later.

The street system has from five to six miles of piping, and for this and the seventeen large warehouses, there is a brine-pumping capacity of 50,000,000 gal. daily; this is used in hot weather. The brine-temperature drop between leaving and returning to the plant is maintained at 6 deg. F.

The temperature drop due to radiation in piping in this system is less than 1 deg. F., and the leakage loss through the system is a small percentage of the total pumped. Brine for this system is circulated by two large compound plunger pumps of the pot type and one turbine-driven centrifugal pump. Centrifugal pumps in the basement furnish brine to the warehouse system. The ammonia-head pressure is 180 lb., the back pressure on the warehouse system 40, and that on the street system 17. The brine is pumped into the system under 90-lb. pressure at the pumps.

The ammonia condensers are of the shell type, rated normally for 2500 tons daily, but they are often run at heavy overloads during the summer to keep down the investment and overhead charges on condenser equipment. Water from the harbor is used for cooling purposes and is first pumped through the ammonia condensers above the engine room; then it is dropped through the surface (steam) condensers before reaching the main outlet.

The boiler room has five 350-hp. stoker-fired water-tube and five 300-hp. hand-fired Scotch boilers using New River coal. The two main electric (alternating-current) generators are turbine driven and of a total rated capacity of 1000 kw. and 450 volts at 3600 r.p.m.

Boiler-Room Practice at the Plant

The boiler-room is the logical place to begin a study of the plant.

Perhaps because the management did not realize how rapidly its business would increase, is the reason for the now disadvantageous location and arrangement of the boilers and stack. The boiler room, or much of it, is built on a wharf or pier with the high-water level near the boiler-room floor. This makes ash hoppers and a conveyor under the furnaces practically impossible. Instead of the stack being located between and at one end of the two rows of boilers, it is at one extreme corner of the house. When there was only one row of boilers (the Scotch), this location was not bad, but now, with two rows, the breechings of the second row, or the water-tube, had to be carried to the ceiling, then across the boilers, where they connect with the header or main flue, which had to be placed directly over the old main flue for the Scotch boilers. Then these two mains connect with the trunk flue and economizer chamber. The work was costly and the construction productive of much friction of the gases.

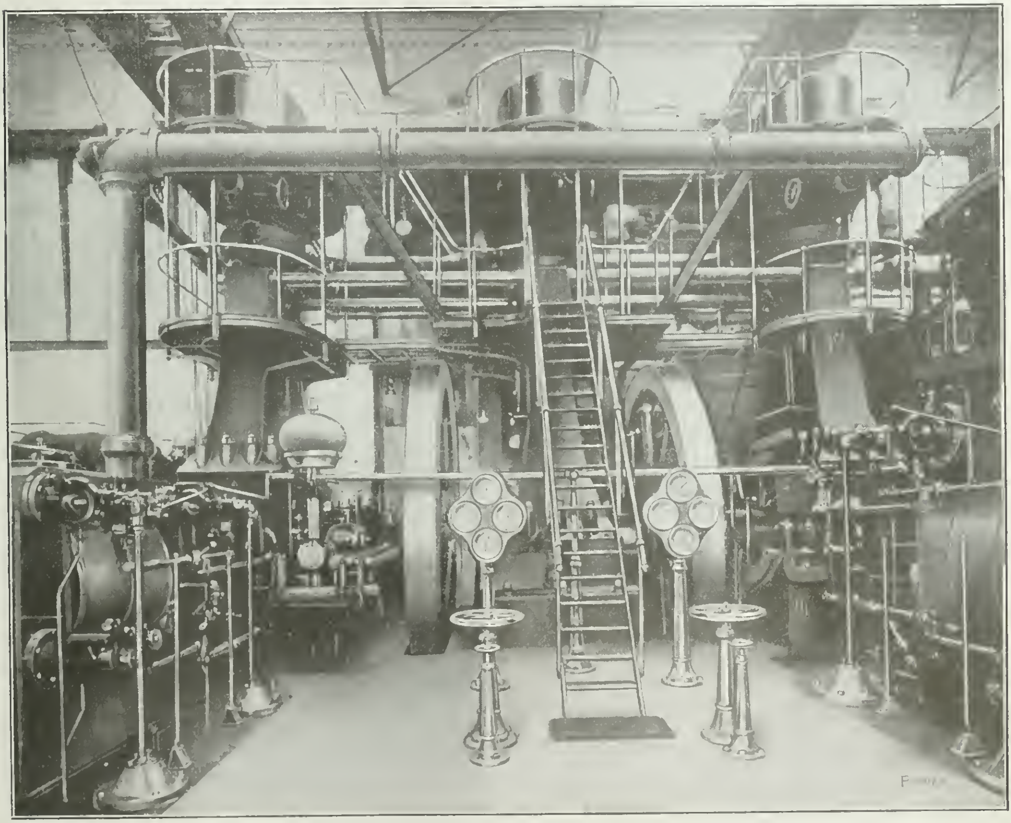


Fig. 1. The 1000-Ton Ammonia Compressor at Sargent's Wharf

This is the largest refrigeration machine ever built

Draft

The Scotch boilers are used comparatively little, for they cannot be as successfully and economically operated at high ratings as the water-tube, which are the long-tube Stirling. These water-tube boilers are provided with underfeed stokers, forced draft being furnished by one 140-in. fan, having duplicate engines. Two 140-in. fans supply induced draft, one at a time being used. They are in duplicate and each has its own engine, for they are more susceptible to service interruptions than the forced-draft fan, which does not receive the gases as do the former.

The furnaces have combustion-control appliances, indicating and recording gages and a CO_2 recorder, the average CO_2 being 10 per cent.

The Coal, Its Handling and Storage

New River coal is used, averaging about 14,900 B.t.u per lb., 4½ per cent. ash, 16 per cent. volatile and having an ash-fusing temperature of 2650 to 2675 deg. F. It is from the McAlpin and Slab Fork mines, and costs $3.65 per ton "alongside," i.e., in the boat alongside the bunker. The coal consumption increases continuously and this year will be about 25,000 tons, or an average of 68.5 tons per day, the average for the summer months being much higher.

The new coal bunker, Fig. 2, built on a new wharf or pier, has a capacity of 5000 tons. It is of wood construction and rectangular in cross-section. The flat bottom has many gate outlets, but those down the center line will be mostly used. If a shortage occurs, the coal stored along the sides (about 600 tons) can be drawn out easily. It will later be machine-conveyed into the boiler room and dumped into the stoker hoppers; now it is handled by car and by hand shoveling.

The annual coal consumption (25,000 tons) is a little more than that amount, for which it pays to install coal-hoisting and handling equipment. In Boston a stevedore with mast and gaff will unload coal for 25c. per ton, so that at the present consumption, the coal handling would cost $6250 annually for stevedore service alone; this sum more than covers interest and other charges resulting from the investment. The hoisting equipment is electrical, everything except the motor being large enough for expected increase in the amount to be handled. As this increases and more coal must be hoisted in a unit of time, another motor of larger power will be used and the cycle of handling increased.

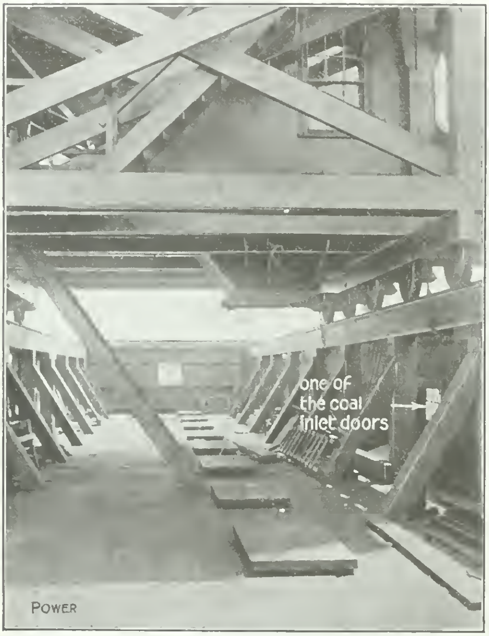


FIG. 2. TOP OF THE NEW COAL BUNKER

As the coal is dumped from the buckets, it runs over an inclined bar-grating, where all pieces under 2 in. pass through into the distributing hopper, which runs on a track, see Fig. 2 and 2a, over the bin. That which does not go through passes on to a crusher before getting into the hopper.

Fig. 2a is a view of the top of the bunker, looking toward the main building. To facilitate chuting coal into both the side doors and the hatchways, the chute telescopes, that part now in the hatchway being drawn up by a block and fall. With the chute in its present position it may be telescoped, and, by means of another block and fall, swung over to discharge coal into one of the side doors as shown by the dotted lines.

Many engineers favor steam instead of electrically driven hoisting equipment. With steam, the usual practice is to hire an engineer to run the hoist when unloading. Sometimes labor troubles arise with these men and shipments cannot be unloaded on time and, of course, demurrage charges go on in the meantime, besides, perhaps, emptying the bunkers of their supply. It was to avoid all possibility of these conditions being brought about that the electric equipment, which will be operated by one of the plant engineers, was installed. A foot switch is provided in the main circuit, so that should the operator fall or meet with any other accident, all steel-band solenoid-operated brakes in series with the switch will immediately bring the whole system to a stop.

BOILER OPERATION

The boilers are run at 200 to 250 per cent. rating for long periods. These ratings, it should be understood, last for days, and often weeks, so the practice is different from that in many central stations where such ratings apply only during the peaks. The duration of these high ratings is one of the chief reasons for using a coal with such a high (2650 to 2675 deg. F.) ash-fusing temperature. With this high fusing point and low ash content ($4\frac{1}{2}$ per cent.) clinker troubles do not exist, and therefore it is not necessary to frequently take boilers off the line to clean and repair furnaces. If the fusing point were lower, say 2200 deg. F., this latter condition would, perhaps, exist and the cost of labor and maintenance in the boiler room would increase, although Mr. Fairbanks claims that this type of boiler can be taken off and put back on the line again for a cost of $2.50, including coal, labor, in fact all except repair costs.

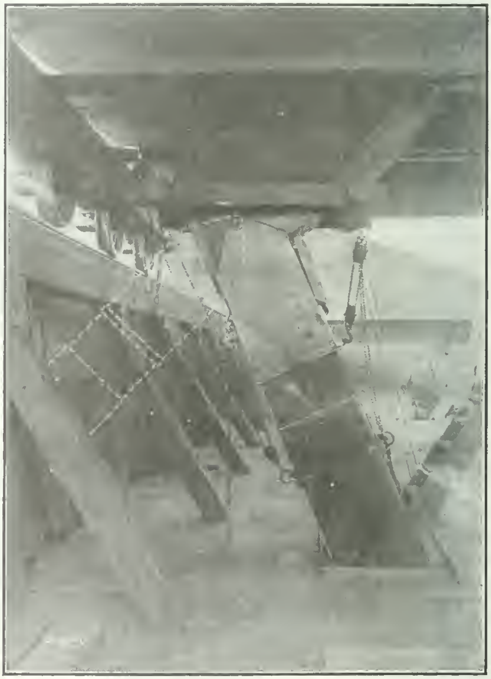


FIG. 2a. THE CHUTE DELIVERS TO THE HATCHWAYS AND TO THE SIDE DOORS

When the load drops in winter, the boilers are cut out until those left in service have to run at 200 per cent. rating. The pressure carried is 160 lb.

Later, it is planned to handle the ashes with a steam ash ejector similar to systems aboard ship. At the company's Richmond St. plant, the services of one laborer in the boiler room have been eliminated by making the ashpit about 2½ ft. deeper than is usual with hand-fired boilers. A night's accumulation may be left in the pits for removal by the day force instead of keeping a man on nights chiefly for this purpose.

COMBUSTION CONTROL

It is well known that where fuel and load conditions remain uniform for long periods, it is possible to adjust the draft and thickness of fuel bed to get the best furnace efficiency. These conditions prevail at the Sargent's Wharf station. In addition to the recording and indicating draft gages, the combustion (draft) regulator and pyrometer for the flue gases, steam-flow meters are being put on the boiler fronts. Alongside and in cases to match, dial gages will be provided and calibrated to show the amount of opening of the back dampers. Adjustments will then be made for varying loads and these gages again calibrated to read in horsepower output, as indicated by the steam-flow meters, the aim being to give the firemen every convenience to assist in getting the best results. Almost identical control systems have been used with fair success in plants where the load and coal were not as uniform, therefore good results are expected at Sargent's Wharf. A double control is used, owing to the boilers using induced and forced draft.

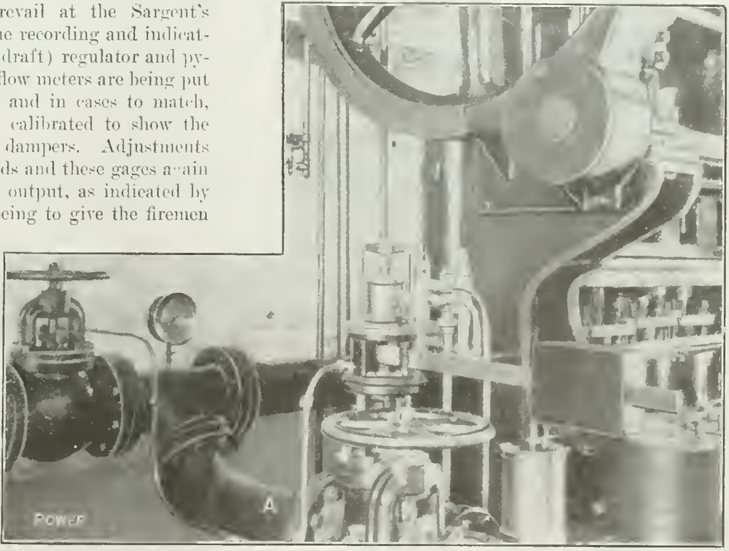


FIG. 3. REGULATOR ON SHUNT BETWEEN SUCTION AND DISCHARGE OF MOTOR-DRIVEN TRIPLEX FEED PUMP

THE FEED-WATER SYSTEM

City water is used for feed and its control throughout is automatic. Besides the economizer, there is a primary heater into which the water enters at an average of 65 deg., passing at 100 deg. into the heater through which the hot ammonia gas passes on its way to the condensers. This heater conserves an appreciable part of the heat absorbed by the brine. The exhaust-steam heater taking steam from the auxiliaries passes water to the ammonia-gas heater also at about 175 deg. F. From the latter, at a higher temperature, the water passes into the economizer, to which the flue gases come at about 450 deg., the water leaving at about 275 deg. A recording thermometer is connected to the discharge line to the boilers. An average of 10 lb. of water is evaporated per pound of coal as fired.

The economizers are set differently to common practice in that the water does not enter the bottom header. Instead it enters the top one, which is blanked off with a partition between the second and third row of vertical tubes. As economizers are usually set, the cold water runs the length of the bottom header, a fraction of the total rising up through the tubes throughout the length of the economizer. Sometimes this gives rise to leaks all along the bottom header. But at Sargent's Wharf all the cool water must pass through two rows of tubes at right angles to the flow of gases, absorbing considerable heat, owing to the large temperature difference, before it may pass to the rest of the tubes. This way of passing the water, allowing for the size of the economizer, would seem to account for the very low gas exit temperature.

THE AUTOMATIC FEED CONTROL

A 6½ and 10 by 6-in. compound duplex plunger pump and a 6x10-in. induction-motor-driven triplex pump are now used for boiler-feed purposes. A spring-loaded regulating valve operated by the discharge pressure is connected in the steam line to the duplex pump, Fig. 3. To prevent too great pressure in the discharge from the triplex pump, a weight-loaded regulator connected into a shunt *A* across the suction and discharge pipes allows the discharge water to flow back into the suction chamber. Two large injectors are provided for emergencies.

It is quite generally known that with fluctuating loads on the type of water-tube boiler used in this plant, the water level in one of the drums fluctuates widely, but this is not serious and occasions no alarm. The condition, however, is rather unfavorable to the use of automatic feed-water regulators, for while there may be sufficient water in the boiler, the circulation, when suddenly forced heavily, tends to "bank up" the water in one drum, causing the level in the other drums to drop. This makes an automatic regulator operate when not needed. At the Sargent's Wharf plant, the load is quite constant and the water level uniform, so that the "automatics" work most satisfactorily. All boilers have nonreturn valves with steel bodies and nickel-steel seats. Between each nonreturn valve and nonautomatic stop valve there is a relief drip to assure that the boilers will not accumulate condensate which might otherwise get by the valves.

About eight years ago, Mr. Fairbanks replaced all gate valves for steam and ammonia by globe valves, partly of his own design. This caused some adverse criticism at the time, but many now approve of the practice. In Europe, particularly in Germany, globe valves are used almost exclusively for superheated steam, as is becoming the practice here, for there is less distortion with globe than with gate valves. The disks are of conical frustum form, and they and the seats are of 90 per cent. nickel and 10 per cent. tin composition; the bodies are of steel.

AUTOMATIC STARTING OF AUXILIARIES

Many engineers prefer to drive auxiliaries by motor, but hesitate because of fear of service interruptions due to failure of the electric supply to the motor. At the Sargent's Wharf station it is planned to use motor drive normally for all auxiliaries, such as feed pumps, draft fans, circulating pumps and exciters. As duplicate auxiliary units should always be installed, all duplicates will be turbine-driven, these units being automatically put into service when the motor-driven ones begin to stop.

LOW-VOLTAGE "BREAKER" IN EACH MOTOR CIRCUIT

There will be a low-voltage circuit-breaker in each motor circuit, which will open when the voltage in that circuit begins to fall. The throttle valve in the steam line to the turbine will open electrically when the breaker does and start the steam-driven auxiliary. Assuredly this is good practice. Take the case of exciter units, for example. With this arrangement of control, the turbine-driven unit could be made to cut in on the line supplying excitation current before the other "dying" unit had come to a standstill, thus enabling the main unit to immediately regain its partly lost load. The same is true for all the other auxiliaries. For the feed pumps, non-return valves would be connected into the discharge from each pump and in this way keep the line pressure off the idle one until it had built up its own pressure after starting.

The second article of the series will treat of the interesting features of the 1000-ton ammonia compressor in the Sargent's Wharf station.

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Side-Feed Stokers*

BY OSBORN MONNETT†

SYNOPSIS—Application of this stoker to return-tubular boilers and water-tube boilers of horizontal and vertical types. Instructions for starting, carrying the load and for banking fires.

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Under this classification come stokers consisting of two inclined grates feeding from the side with a clinker bar at the bottom. It should be a fixed rule that no such stoker should be placed under a boiler without a full extension setting. This enables the heating surface to be worked to a maximum and gives the long flame travel required. To operate this stoker without smoke requires careful attention. Its construction is such that the fuel will easily slide down from the hoppers onto the grates, and when it does, smoke will be produced. The average fireman will poke this stoker to take care of fluctuations in the steam pressure, and invariably smoke is the result. Fluctuations in the steam pressure should be taken care of by the stoker engine. Poking should be limited and confined to the lower part of the stoker, where clinkers must sometimes be pulled out through the front door.

To insure a proper mixture of the gases when this stoker serves a return-tubular boiler, a two-span deflection arch is of the greatest value. Such a setting for a Model stoker is shown in Fig. 1. The combustion chamber should be excavated to the floor line and the deflection arch be set back far enough to make sure that the temperature will not become too high. The action of the arch is to interrupt the stratified flow of volatile matter that is distilled off at times when poking occurs or where an unusual amount of green coal slides into the furnace.

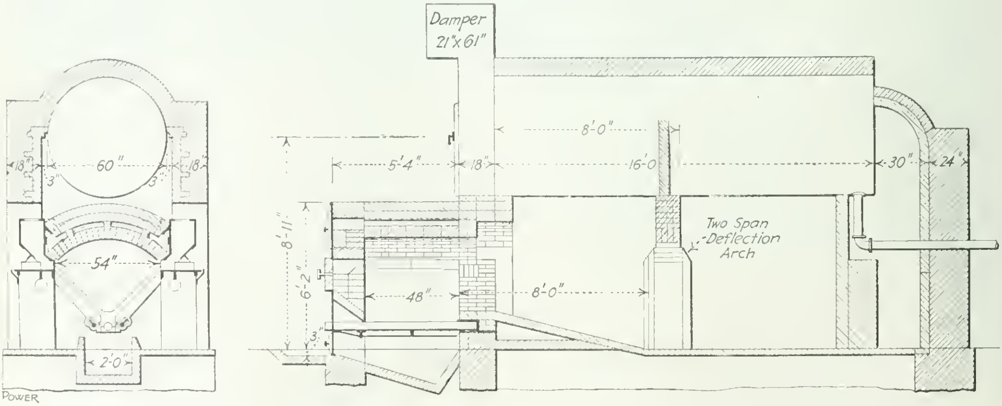

FIG. 1. RETURN-TUBULAR, 100-HP. BOILER WITH MODEL STOKER AND DEFLECTION ARCH

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†Smoke Inspector, City of Chicago.

This type of stoker can be applied easily to any type of horizontally baffled boiler or tile-roof furnace. Fig. 2 shows a Model stoker in connection with a Hawkes boiler and a two-span deflection arch. The furnace action is exactly the same as in the previous installation. The extension is 5 ft. 7 in. from the flue caps and there is plenty of area through the deflection arch to prevent bottling the heat. Besides, T-tile has been placed on the water tubes for a distance of 36 in. from the front header to cool off the furnace at this point to a good working temperature without affecting the smoke performance.

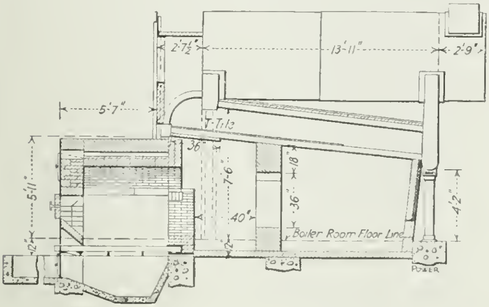

Fig. 2. Model Stoker and Deflection Arch in Two Spans Serving 150-Hp. Hawkes Boiler

A satisfactory installation of Detroit stoker and Worthington water-tube boiler is shown in Fig. 3; the extension in this case is 10 ft. 9¼ in. from the boiler casing. The headroom to the top of the main drum is only 9 ft. from the floor line. The ashpit has been excavated 2 ft. 8 in. The results are a large capacity on low headroom with a long-flame travel and good smoke performance.

In applying the side-feed type of stoker to vertical water-tube boilers, it is not sufficient to set them close up against the heating surface. If this is done there will be times when the volatile matter passing off will make continuously No. 1 or No. 2 smoke on the Ringelmann chart. There should be a distance of at least 5 ft. between the end of the stoker arch and the nearest heating surface, as shown in Fig. 1. This space should be roofed by a step-up secondary arch, so that long-flame travel will be insured. Such an installation can be run satisfactorily from a smoke standpoint if the stoker is carefully handled.

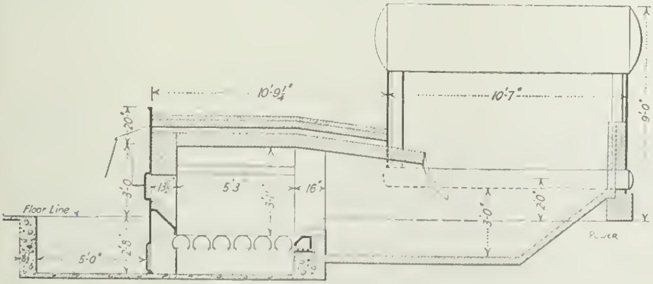

Fig. 3. Worthington Boiler, 150-Hp., and Detroit Stoker

Probably one of the most successful settings of this type of stoker that has come under the observation of the author is the installation shown in Fig. 5. It is a B. & W. boiler with Sewell baffle, equipped with a Murphy stoker and a deflection arch. The headroom under the boiler is 8 ft. 6 in. and the stoker is set full extension. A two-span deflection arch is set midway in the combustion chamber with ample area under the spring of the arches. One of the successful features of the furnace is the baring of the tubes at the front header for a distance of 4 ft., thus increasing the heat absorption and decreasing the temperature and brick maintenance. Then there is 4 ft. of box tile to the deflection arch, and T-tile is again used to the end of the first baffle. This unit runs satisfactorily from a smoke standpoint and is efficient. It was originally set without the deflection arch and with a complete baffle of box tile, but the performance since the alterations were made is much better than before.

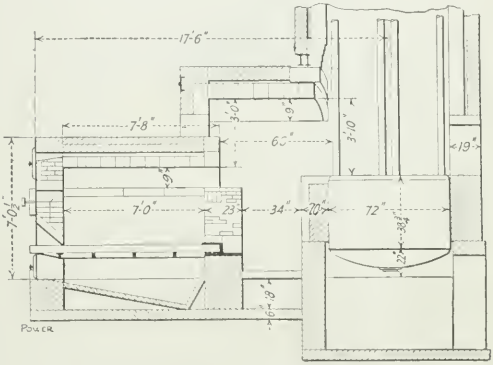

Fig. 4. Wickes Boiler of 200-Hp. Capacity and Model Stoker

Another setting of a Murphy stoker with long-flame travel on a tile roof is shown in Fig. 6. The installation serves a Heine boiler and is a typical layout for horizontally baffled boilers. Under no circumstances should the furnace be set flush in such installations as they do not work out to advantage.

On a Stirling boiler anything less than full extension furnaces should not be considered. Fig. 7 shows the flame travel obtained on a Stirling boiler with a Murphy stoker set full extension. This is the only arrangement that can be expected to give a good account of itself.

Operation of Side-Feed Stokers

Starting Fires—Cover the clinker bar with wood to prevent the fuel from running into the ashpit. Fill up the hoppers and work in by hand enough coal to cover the grates. Place a small amount of clean wood kindling on top of the coal and ignite it. After the fuel is burning well, feed the coal onto the grates by hand until the arch is hot and the stoker can take its regular load; then it can be operated by the stoker engine. When the engine it attached, the clinker-bar connection should be left off until it is found necessary to work the clinker bar. When refuse accumulates sufficiently at the lower ends of the grates, connect the clinker bar to the operating mechanism, making sure beforehand that the bar will work freely and is not caught by fresh coal or clinker.

Carrying the Load—Always keep the hoppers full of coal. If this is not done, there will be a sliding of coal into the fire when the hoppers are replenished. This will cause smoke. Feed the coal continuously so that no large amount will be necessary at any one time. If this is done, the volatile matter passing off from the coal regularly fed will not be in excess of the capacity of the furnace to burn it. If the stoker is fed intermittently, there will be too much fresh coal in the furnace at one time and smoke will be made. Never poke the fire on the upper grates. In using the roust bar, be careful to see that no sliding of the coal occurs. If it becomes necessary to work the fire on the lower grates, handle the clinker carefully in order that there will be no avalanching of the coal from the top of the furnace. Regulate the thickness of the fire according to the draft and to the load. A thickness of from 3 to 8 in. is permissible. Fine coal or low draft calls for a thinner fire than coarser coal or good draft. Ordinary fluctuations in the load can be taken care of by regulating the ashpit doors. Do not close the damper on a heavy fire. It should never be closed to such an extent that there will be less than 0.15 in. draft over the fire while in operation, or smoke is likely to be made. This applies especially to plants having damper regulation.

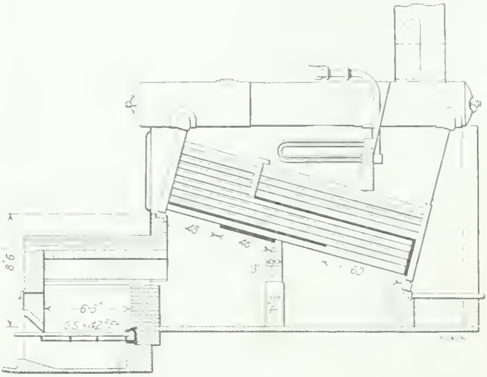

FIG. 5. B. & W. 200-HP. BOILER EQUIPPED WITH MURPHY STOKER AND TWO-SPAN DEFLECTION ARCH

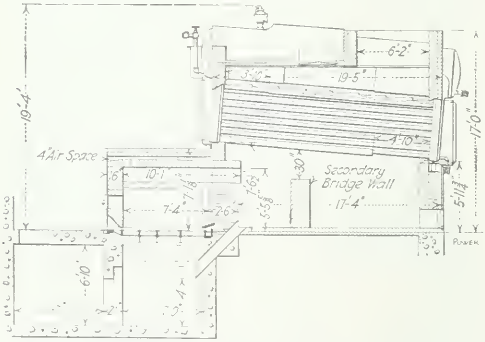

FIG. 6. TYPICAL HEINE BOILER SETTING WITH FULL EXTENSION MURPHY STOKER AND NO. 8 MIXING PIERS

Banking Fires—Run the side magazines empty. Pull the coked coal down to the bottom of the furnace and cover it with 25 or 30 scoops of fresh coal through the middle door. Leave the fire door open for a short time after the fire is banked and until the arch has cooled down, after which the ashpit doors and damper can be closed.

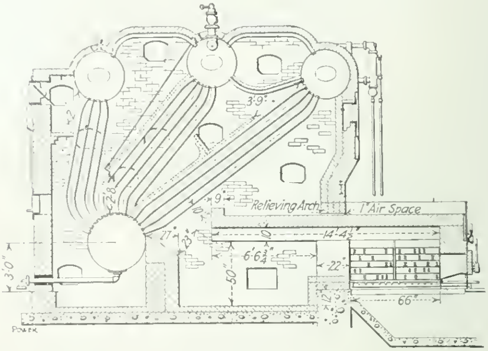

FIG. 7. CLASS P STIRLING BOILER, 133-HP., WITH FULL EXTENSION

In starting up after a shutdown, break up the bank with a hook and feed green coal carefully down the sides, with the damper partly open, until the fuel on both sides of the furnace is ignited. When the arch gets hot the damper can be opened wide and regular operation commenced.

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Low-Voltage Direct-Current Generators

By GORDON FOX

The low-voltage direct-current generator, which is used extensively for electroplating and electrochemical work, differs in many essentials from machines of higher voltages. The low voltage is accompanied by an extremely high current rating and the provisions for conducting and collecting these heavy currents are the distinguishing points of difference in design.

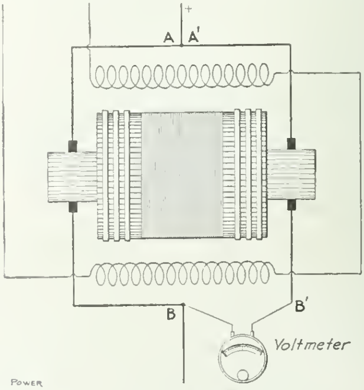

DIAGRAM OF DOUBLE-COMMUTATOR LOW-VOLTAGE GENERATOR

Armature conductors of generators of this type are almost always of the bar coil type, usually with a single-turn coil and the armatures are lap-wound to give as many parallel paths as possible. The commutator segments are few and wide. Since the coils have but a single turn and the voltage is so low, there is little tendency toward sparking from armature induction effects, but to collect the heavy currents without undue heating of the commutator or brushes requires special provisions. Since the armature induction is low the use of copper gauze or composition brushes is allowable. Gauze brushes are perhaps the most common and the best for the majority of cases; copper leaf is sometimes used and a special brush utilizing copper gauze embedded in graphitic carbon sometimes finds application. If gauze or leaf brushes are used they should be set without too great angularity to the commutator, an angle of about 30 deg. being preferable. If possible, they should be staggered to prevent grooving of the commutator. The brush pressure must be fairly heavy but should be no more than is necessary to collect the current without burning the brush tips from high-contact resistance.

Many low-voltage machines of this type are provided with double-armature windings and two commutators to obtain more commutator surface and an even distribution of load. One commutator is mounted at each end of the armature. The two windings usually occupy the same slots but the coils face in opposite directions. This arrangement virtually provides two separate windings in parallel under the same field poles.

It is a familiar fact that the voltage of a generator and its load-voltage characteristics may be altered to some extent by shifting the brushes. Now consider the case of two separate armature windings in parallel, both under the same field poles; this corresponds to the double-ended, low-voltage machine. Since the rheostat adjustment affects both windings similarly, their voltages cannot be equalized through manipulation of the field strength. It follows that the relative brush positions upon the two commutators must be such that the same characteristics will be secured from both armature windings. To attain this end it is best to first properly space the brushes upon both commutators. Then run the machine, using only one commutator, setting the brushes on this end by shifting the rocker-arm until good commutation and minimum heating occur. Next, determine the leads of like polarity, such as *A-A′* and *B-B′*, and connect together *A* and *A′*. Place a low-reading voltmeter between *B* and *B′*. Shift the rocker-arm on this second commutator until the voltmeter reads zero. The two armatures are now delivering the same voltages and have like relative positions. The leads *B* and *B′* can now be connected together with the knowledge that the two windings and commutators will properly share their loads.

It is evident that if the two armatures are connected in parallel without this procedure, it is likely that their voltages will be unequal and there will be local current flowing through the closed circuit of the two armature windings. This local current is a waste, which lowers the efficiency of the machine and increases its heating.

Where possible, it is desirable to provide separate excitation for the field coils of low-voltage generators. This excitation may be at 110 or 220 volts, whichever is available. Where these generators are self-exciting it is not infrequent that difficulty is experienced in getting them to build up, because the very low voltage generated by the action of the residual magnetism upon the one-turn coils is not sufficient to force an appreciable current through the shunt-field winding.

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Openings Between Boiler and Engine Rooms—The openings around all pipes where they pass through the wall from the boiler room to the engine room should be thoroughly stopped up with asbestos or other suitable material. An engine room makes a poor appearance when smoke from the boiler room enters it through the space left between the pipes and the pipe thimbles and blackens the walls in streaks directly over these openings.

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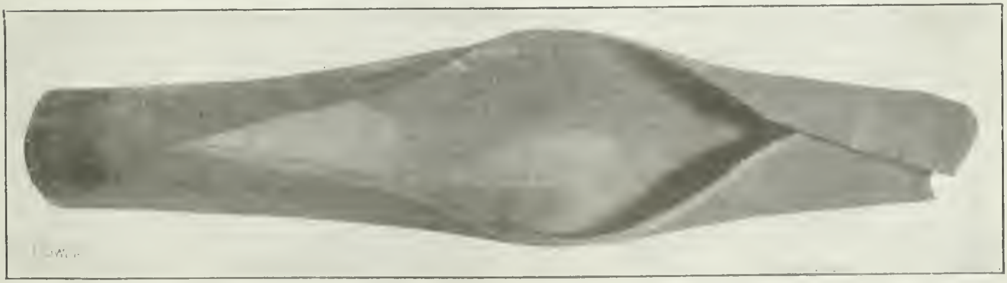
Burst Boiler Tube



Tube failures are the cause of more aggregate damage than any other one thing about the boiler plant. An explosion of a shell boiler is more spectacular, but there are not so many of them. This is the reproduction of a photograph of a recent example. It was a welded tube, but these seem to be no more liable to failure than the seamless variety; only, when they split in the weld, as this did, the split is apt to run for a greater length. Frequent inspection and the replacement of all tubes showing any tendency to bulge or to local distortion appear to be the best means so far devised for the prevention of such damage. The high rates of evaporation at present in use are responsible for much of the trouble. Scale or oil, which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface, are very likely to make trouble when the evaporation goes up to six or ten.

Safety Rules for Operation of Electrical Equipment

The Bureau of Standards has recently issued, under the title, "Circular No. 49," a set of rules to be observed in the operation and maintenance of electrical equipment and lines. These rules have been compiled after a year's study of those of many of the large companies, aided by suggestions from commissions, company officials, workmen, etc. Space does not permit our giving the rules in full, but such items are included as should be particularly helpful to our readers. Complete copies of the report may be had from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents each.

GENERAL

Attendance—A qualified employee shall be kept on duty where generators or rotary converters are operating, excepting small, low-voltage generators for telephone and similar work.

Two Workmen—There shall be at least two employees on any work near exposed live parts of equipment and lines above 750 volts in stations, in testing rooms, and on overhead lines, or above 150 volts from earth in underground construction where it is necessary to approach such parts within the distances later specified.

Diagrams for Chief Operator—Diagrams showing plainly the arrangement and location of all parts of the electrical equipment and lines must be maintained on file with the chief operator.

Accident Reports—Report blanks shall be issued to each employee and their use required for reporting to the employer each personal injury on or about the equipment and lines. These shall contain at least the following information and shall be filled out at the time of the accident:

(a) Date, time and locality.

(b) Age and nationality, and does person speak English?

(c) Regular occupation, occupation at time of accident and years of such occupation.

(d) Extent of injury.

(e) How did accident occur?

(f) Was original cause of injury electrical or otherwise?

(g) What defects of construction, protection, illumination or carelessness were concerned in the accident?

(h) Were other employees present?

(i) What first aid was given, how soon after the injury and how long continued?

(j) Suggested improvements for preventing similar accidents.

(k) Voltage.

Treat Everything as Alive—Electrical lines and equipment should always be considered as alive unless positively known to be dead.

Safety Appliances—Employees at work on or near live parts should use the safety devices and special tools provided, first making sure that they are suitable and in good condition. Safety devices may get out of order or be unsuited to the work in hand.

Duties of Chief Operator—The chief operator shall keep a log-book showing all changes in the conditions of operation, including the starting and stopping of electrical supply equipment, the location and nature of work started or completed, the name of each foreman locally in charge of work and all unusual occurrences or accidents.

He shall sign the log-book when assuming duty and before being relieved.

He shall keep within sight an operating diagram or equivalent device indicating whether electrical supply circuits are open or closed and where the work is being done.

It shall also be his duty to enforce the safety rules and to permit only authorized persons to approach equipment or lines.

Control of Electrical Supply Circuits—Employees shall secure special authorization from the chief operator before closing circuits or starting equipment, and before opening or stopping them.

Exceptions—In emergencies, to protect life and property, any employee may open circuits and stop moving equipment without special authorization if he is sure that his action will promote safety, but the chief operator must be notified immediately of his action with the reasons therefor.

Authorization for Work—Special authorization from the chief operator shall be secured before work is begun on or about equipment or lines and a report shall be made to him when such work ceases. When there is more than one workman at any place the foreman locally in charge shall secure the authorization.

Reporting Clear—No instructions for making alive equipment or lines which have been killed to protect workmen shall be issued by the chief operator until all workmen have reported clear. When there is more than one workman at a location, the foreman locally in charge of such dead equipment or lines shall report clear for all his workmen only after all have reported clear to him. If there is more than one gang, each foreman shall separately report clear to the chief operator.

Maintaining Service—When circuits above 750 volts automatically open immediately after each of three consecutive closings, they shall be disconnected until they have been found clear by proper test.

When circuits at which men are known to be at work are opened automatically, they shall be disconnected until the chief operator has ascertained that the workmen are safe and until he has given proper authorization.

When circuits feeding supply lines become accidentally grounded, by indication of ground detectors at stations, they shall be opened, and if upon trial closing the ground still exists, the lines shall be disconnected until they have been found clear by proper tests.

Tagging Electrical Supply Circuits—Before work is done on or about any equipment or lines, either dead or alive, the chief operator shall have "Men at Work" tags attached at all points where such equipment or lines can be manually controlled to plainly identify them.

Protecting Workmen—When lines or equipment are to be disconnected from any source of electrical energy for the protection of workmen, the operator must first open the manual cutouts designed for operation under load and then the air-break disconnectors.

Touching Live Parts—No employee shall touch two parts of different potentials at the same time.

Employees shall not touch any exposed ungrounded live parts at any voltage unless insulated from floors and other conducting surfaces by approved insulating covers, mats or platforms. If permanent devices are not provided, portable ones shall be used.

Extra High Potentials—No employee shall come within or bring any conducting object within the distances named below from any exposed ungrounded live part at or above the voltage specified:

Operating Voltage	Distance, Feet
7,500	2
27,000	3
47,000	4
70,000	6

In dry locations these distances may be reduced, if approved insulating or grounded metal barrier devices are placed between the person and such part.

If the part is being worked on directly, the tools or other mechanical appliances used must provide the full distance of insulating material unless protective barriers are also used between the person and the live part.

High Potentials—No employee shall come within or bring any conducting object within 1 ft. of any exposed ungrounded live part whose potential exceeds 150 volts in underground construction, or 750 volts in stations, testing rooms or overhead construction.

In dry locations, this distance may be reduced if grounded metal devices are placed between the person and the part or object. This distance may also be reduced if approved insulating barriers are placed between the person and ground as well as between the person and all other conducting surfaces which he could accidentally touch at the same time.

Where greater space cannot be secured by use of the special insulating tools and appliances furnished or as an additional safeguard, properly tested insulating gloves and sleeves may serve as portable insulating devices between the person and live parts below 7500 volts.

Wire Insulation—Employees must not place dependence for their safety on the insulating covering of wires.

Work from Below—Employees must not work from above on exposed live parts of equipment or lines when work can be done from below. Moreover, they should avoid working on equipment or lines from any position by reason of which a shock or slip will tend to bring the body toward exposed live parts.

Opening and Closing Switches—No employee shall open a cutout not designed for interrupting a loaded circuit unless the circuit has first been interrupted at a proper cutout.

Manual cutouts shall always be opened or closed by a single unhesitating motion and, if possible, with one hand. All cutouts shall be handled only by means of the insulating handles provided.

Loose Wires—Loose conductors should never be brought near exposed live parts except those to which they are to be immediately connected.

Handling Connecting Wires—In connecting dead equipment or lines to a live circuit by means of a connecting wire or device, employees shall first apply the wire to the dead part before attaching it to the circuit. When disconnecting, the live end shall be removed first.

Never Open Series Circuits—Series circuits or secondaries of current transformers shall never be opened. A jumper must always be connected across any device inserted in such a circuit before working on the device.

Applying Grounds—In applying a grounding device to normally live parts, the device must be grounded before bringing it near the parts, and must be removed from the live parts before removing it from the ground connection.

KILLING SUPPLY EQUIPMENT AND LINES

Ascertain if Parts Are Dead—No employee shall approach any exposed ungrounded part, normally alive, within the distances specified, except as allowed in these rules, unless he has first assured himself of his own safety and that of those working under his direction by taking the following precautionary measures in the order given:

Foreman's Request—The foreman locally in charge of the work shall request permission from the chief operator to have the particular section killed.

The chief operator shall at his discretion advise the foreman that the particular section will be killed and that instructions will be given the foreman when he can safely proceed.

Opening Disconnectors and Tagging—The chief operator shall direct the proper persons to open all disconnectors, including suitable air-break cutouts, through which electrical energy may be supplied to the particular section to be killed, and shall require each person to lock each disconnector open and to tag the same, and each tag shall state in large letters "Men at Work."

Protective Grounds—When all the disconnectors designated have been opened, locked and tagged, the chief operator shall require each person operating them to make protective grounds upon the section which is to be killed and to report when such grounds are in place.

Permission to Work—Upon receipt of information from all persons operating disconnectors that protective grounds are in place, the chief operator may advise the foreman that he may proceed to work, considering the specified lines or equipment dead.

Foreman's Record and Grounds—The foreman shall record on a card the time the lines or equipment are reported dead, the particular lines or equipment specified, the name of the chief operator and sign his own name. He shall then immediately proceed (except in underground systems) to make his own protective ground on the disconnected section of the equipment or lines in the manner specified.

Grounds shall be made on the dead equipment or lines between the particular point at which work is to be done, and each disconnector which has been opened by the above procedure for his protection.

Proceed with Work—After the section has been killed, the foreman and those under his direction may proceed with work on or about the dead section.

Reporting Clear—Each foreman, upon completion of his work and after assuring himself that all the men under his direction are in safe positions, shall remove his protective grounds and shall report to the chief operator that all tags protecting him may be removed and record the time of such report on his record card.

Reporting Removal of Tags—The removal of any tag from any disconnector shall be reported immediately to the chief operator by the person removing it.

Upon the removal of any tag there shall be added to its record the name of the chief operator, the time of removal, who requested it and the signature of the person removing the tag. The tag shall then be filed with the chief operator.

Restoring Service—Only after all protecting tags have been removed by the above procedure from all disconnectors shall the chief operator, at his discretion, direct the removal of locks or blocks and of protective grounds and the closing of any or all disconnectors.

Care About Machines—Do not allow oil cans, tools and wiping cloths to catch in moving parts of machinery. In passing any machine in operation, be careful not to touch it or allow tools or other pieces of metal to touch the machine or its connections. Do not use iron or tin oil cans near field magnets. Use only oilers and wipers with insulated handles around commutators, switches and other electrical equipment.

Loose Clothing—Avoid loose clothing about moving parts of machinery and do not wear shoes that slip easily on the floors about live or moving parts.

Killing Parts Worked On—Do not work on any normally live or moving part, feeling assured that it is not alive or will not move, unless you have first protected yourself against danger by having the live or moving part killed.

Open Flames—Do not smoke or bring open-flame devices into storage-battery rooms.

Report Defects—Promptly report any broken or unsafe tools, defective safety appliances, apparatus or any dangerous condition of equipment or surroundings.

SWITCHBOARD OPERATION

Care about Live Parts—Do not work on or near exposed live parts unless authorized to do so, and then strictly observe the rules laid down for such procedure.

When working near fuses and circuit-breakers be careful to avoid injury from their operation. If the hands are exposed to flashes, wear insulating gloves.

When working on one section of a switchboard or in one compartment, mark it conspicuously and place barriers to prevent accidental contact with other sections or entrance into other compartments.

Handling Switches and Fuses—Do not open manual cutouts which are not designed for opening loaded circuits unless the circuit has first been opened at a proper cutout.

When operating manual cutouts, keep the body as distant and as far below as possible and use only one hand.

In handling fuses or switches, use only the insulating handles or the special rods or tongs provided. In handling voltage transformer fuses, always stand on an insulting mat or platform.

Never replace nor remove link fuses from live terminals.

When cable plug connectors are used, do not allow one end to remain loose while the other is connected to a live terminal.

Protecting Others—Do not report lines or equipment dead for other men to work on until the lines or equipment have been cut out by air-break manual cutouts, protective grounds have been applied to the parts so cut off and "Men at Work" tags have been attached to the cutouts.

Also, in reporting, identify the parts by position, letter or number as well as by description.

Report to Chief Operator—Report to the chief operator any unusual conditions of load, the opening of any automatic cutout and the indication of any ground on a normally ungrounded outgoing circuit.

Closing Circuits—Do not again close circuits above 750 volts which have automatically opened immediately after each of three consecutive closings within 10 min. without special instructions from the chief operator.

Do not again close any circuit opened by automatic cutouts if persons are known to be working on the circuit.

Handling Switchboard Equipment—All metal parts of equipment on switchboards shall be handled as if operating at the highest voltage to which any part of the equipment on the same switchboard panel is subject, unless the parts are known by test or otherwise to be free from such voltage.

Accidental Grounds—When an accidental ground is indicated on a normally ungrounded circuit immediately open the circuit. If upon a trial closing, it is found that the ground still exists, open again, and do not again close without special instructions from the chief operator.

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Steam in Gas Producers—As to the amount of steam required to operate gas producers, there is but little authentic data and no general rule can be given. The character of the coal used has much to do with this question as more steam is needed for coal which clinkers badly than for that which does not. The size of the gas mains and the capacity at which the producers are worked are also determining factors. In a general way, however, it may be stated that under ordinary conditions not more than from 2 to 5 per cent. of the heat units in the coal are needed to generate sufficient steam. As some of this heat is returned to the producer, the actual loss is less. If possible, the steam used should be superheated to prevent condensation and moisture for, if wet steam is introduced, a chilling action might result from reëvaporation. It has also been found that a hot blast gives better results than a cold one. The pressure at which a producer is blown usually ranges from 30 to 40 lb. per sq.in.

Transmitting Power by Rope Drives

By Henry D. Jackson

SYNOPSIS—The advantages and disadvantages of rope drives; the relative merits of the American and English systems; a comparison of cotton rope with hemp.

Rope drives have a number of advantages over belts and, probably what is equally important, a number of disadvantages. The primary advantages are:

1. The distance through which power can be economically and satisfactorily transmitted is much greater with rope drive than with belts. Also, power can be economically transmitted over very short distances with ropes.

2. The amount of power that can be transmitted by rope is limited only by the capacity of the shaft and the space between the bearings, as the number of ropes can be increased to meet the power requirements. This is quite different from belts as it is not easy nor economical to increase the capacity by an increased number of belts.

3. Economy in installation cost and, so long as the drive is properly installed and maintained, low maintenance cost.

4. Less space is required for a given capacity of drive.

5. Steadiness and quietness of the drive.

6. Absence of slip or creep and to a large extent the elimination of static electricity.

7. The ease with which power can be transmitted to shafts at an angle to the driving shaft as well as ease of transmission from floor to floor.

The disadvantages of rope drives are:

1. More or less skill is required to properly adjust and install the ropes.

2. Necessity for the ropes being particularly adapted to the character of the drive.

3. Large diameter of the pulleys, special pulleys being required, which in the case of accidents, may result in long delays for repairs.

4. Necessity for avoiding heavy overloads in order to prevent rapid deterioration of the drive.

The most prevalent trouble is deterioration, owing to overloaded conditions and to the use of too small pulleys. Manufacturers are insistent that the minimum diameter of the sheaves should be at least thirty-six times the diameter of hemp rope and thirty times the diameter for cotton, but there are many conditions in factories where this practice is impossible, and pulleys for hemp rope are used down to thirty times the diameter. This is unwise and has in many instances brought rope drives into disrepute. Where the pulleys are properly designed for the diameter of the rope the drives have given excellent service.

Unquestionably, the use of high-speed machinery, particularly motors, has brought about this condition. However, care should always be taken in the installation of rope drives to make the total yearly cost as low as possible. Low first cost does not always mean low yearly

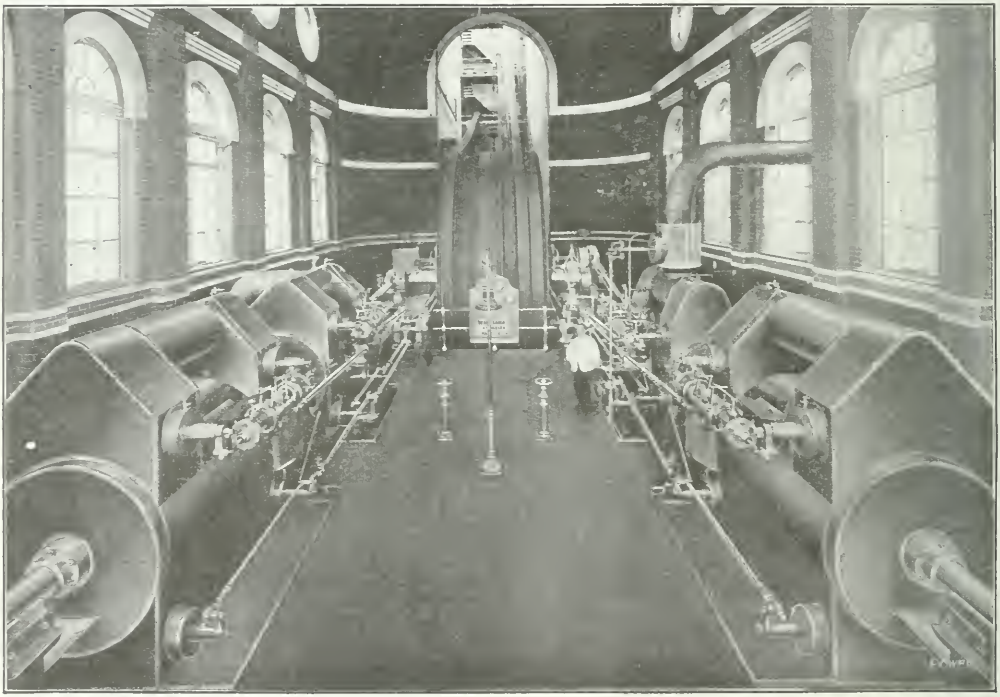


Fig. 1. Showing Typical English Engine Room and Rope Tower

cost, and slow-speed motors with larger pulleys are probably more effective in reducing the total yearly cost from this standpoint than the use of high-speed motors.

There are two distinct types of rope drive, the English and the American. The former consists of a number of single loops, each made endless by splicing or by means of fasteners; the writer does not advise these. Each rope is absolutely independent of any other and carries its proportion of the load. If one rope breaks, the others can continue in service at a slightly reduced capacity unless the owner is willing to take the chance of overloading and, therefore, deteriorating the rope during the period that one is missing. In drives of this character it is wise to design for considerable overload so as to meet this condition without straining any of the ropes.

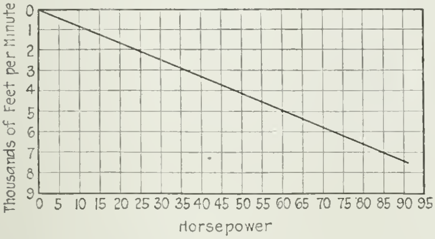


FIG. 2

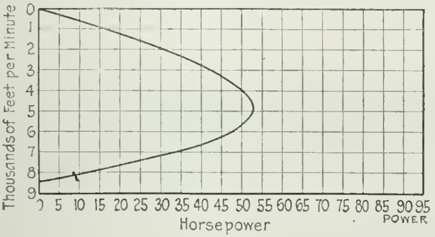


FIG. 3

FIG. 2. TRANSMITTING CAPACITY OF COTTON ROPE
FIG. 3. TRANSMITTING CAPACITY OF HEMP ROPE

The American, or continuous-wrap, system consists of a single rope running from the driving shaft to one or more driven shafts, returning to the driving shaft, and repeating the operation as many times as may be required to distribute the necessary power. The slack is carried to a tension pulley on a traveler and thence to the driving sheave. This system gives good results in many cases and has many advocates; whether it is an improvement over the English system depends upon the point of view of the person using it. Its principal weakness is that a break at any point completely disables the drive. It is complicated to install and is equally so to repair, requiring expert service and taking a long time. The drive is not particularly uniform in its results, owing to the slack traveling from place to place throughout the drive when the load varies on the different shafts, and upon suddenly reaching the tension carriage, causes it to surge and jump.

In general, the main drives from the engine to the main shafting are by the English system. The vertical drives from one shaft to another, if the power is comparatively small, are by the American system. There are plants, however, in which either system is used entirely.

For driving purposes two kinds of rope are employed, hemp, or manila, and cotton rope. In America cotton rope is little used for main-shaft drive. It is used to a limited extent on certain machinery, but in these cases it is almost invariably purchased abroad as no good cotton transmission rope seems to be made in this country.

The characteristics of hemp rope are given in the curve, Fig. 3, from which it will be noted that the economical limit of speed is approximately 5000 ft. per min. Above this speed centrifugal force acts to throw the rope out of contact with the pulleys and the driving power drops off rapidly. The curve is figured upon the basis of the maximum allowable tension being 200 times the square of the diameter of the rope. This tension is on the driving side; that on the slack side will depend on the centrifugal force of the rope and such tension as may be necessary to keep it from slipping.

Manila rope is made from the best grade of manila fiber, which has a high tensile strength but is very weak across the grain and will not stand excessive bending. The fiber is also harsh or stiff, and tends to cut when made in the form of rope and bent, so that the fibers must not be put under excessive cross-strain nor bent to too short a radius. To avoid the troubles incident to this bending, such as local wear or abrasion, the ropes are frequently lubricated. Even under these conditions, the life of manila rope, when operated at or near full load, seldom exceeds ten years. Compared to belts this means that the initial cost of the rope drive must be considerably less to warrant its installation.

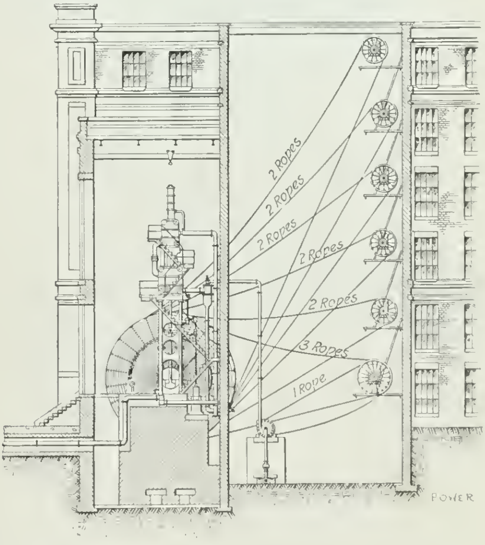


FIG. 4. HIGH-SPEED ENGINE DRIVING SEVERAL LINE-SHAFTS

The early hemp and cotton ropes were three-strand. It was found, however, that three-strand ropes of hemp, except for small drives, did not give as good service as four-strand, particularly those having a central core; also, four-strand rope is more nearly cylindrical and is more likely to assume that rolling motion which is instrumental in lengthening its life.

In direct contradiction to the statements of the American rope manufacturers are the statements of foreign manufacturers. The former claim that the most satisfactory material for rope is manila fiber, while the latter say that cotton is the most satisfactory. The writer has no data as to the actual life of American rope drives, but taking the figures given by the manufacturers, it is fair to assume that the ropes do not last much beyond the ten-year limit. Comparing these figures with the English cotton rope, one finds among the latter a number of drives that have lasted over thirty years. It is true, however, that the English rope costs from one and one-half to twice that of American rope.

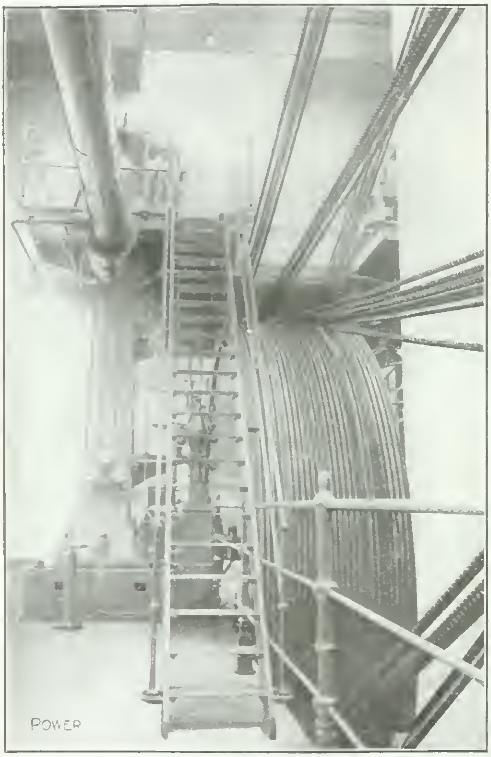


Fig. 5. High-Speed Engine with 1⅝-In. Ropes Transmitting 95 Hp. per Rope; Rim Velocity 7033 Ft. per Min.

According to some American manufacturers, cotton rope cannot transmit as much power as a manila rope of the same size. From their catalogs, a 2-in. manila rope at a speed of 5000 ft. per min. will transmit approximately 51 hp. According to the English rule, a 2-in. cotton rope will transmit approximately 65 hp.; this shows that the tension which may be put upon a cotton rope is greater than that for manila. This is not because a cotton rope is as strong or stronger, for the reverse is true, but, owing to the structure of the hemp and the harsh character of the fibers, it cannot be operated at high tension because the bending under these conditions would tend to make one fiber cut into another.

It is also true that at this speed centrifugal force plays an important part when manila rope is used. Cotton has no such limit as the fibers are soft and mat one upon another without injury; also, with cotton the grooves are so shaped as to make the ropes wedge and centrifugal force is practically eliminated. This makes it possible to exceed 5000 ft. per min.; in fact, one English manufacturer recommends speeds as high as 7000 ft. per min. Moreover, the pulley diameters in this case are thirty times that of the rope, whereas for equivalent service the American manufacturers limit the pulley to forty diameters. This in itself will make considerable difference in cost in favor of the cotton rope.

The cotton rope as recommended is preferably three-strand, permitting the wedging action which tends to eliminate centrifugal force. Fig. 2 shows the capacities recommended for a 2-in. cotton rope at different speeds with the pulley diameter thirty times that of the rope. This curve is worth comparing with that in Fig. 3.

Ordinarily, for vertical drives the continuous system would be used in this country, owing to the difficulty of obtaining a proper wrap on the lower pulley with manila rope. It has been found abroad, however, that with cotton rope no such system is required, the ordinary English wrap being used, and no difficulty is experienced without the use of idlers. This naturally improves the drive by a reduction in friction as well as a decided reduction in the amount of bending.

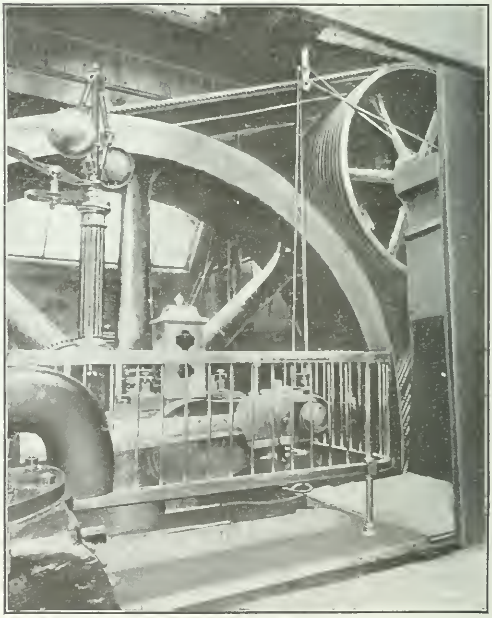


Fig. 6. Rope Drive with Short Centers

The theory has been advanced by the American rope manufacturers that cotton rope is not adapted to service in this country owing to climatic conditions. Two mills here, in widely differing localities, refute this. One has been in operation for over ten years without a single rope being touched; the other, for over twenty years without any change having been made on the ropes.

Certain it is that rope drives have their place and, in spite of the life of the hemp rope being limited, it is largely used. What would be the result if American manufacturers would produce rope costing double that of the present hemp but having a life several times as great and a capacity 30 to 75 per cent. greater? Would not rope drives replace belts in many instances, and would there not be good reason to believe that in many cases where electric drives have been used, rope drives would be installed with greatly reduced first cost and a probable reduction in the operating cost?

The generally accepted opinion here is that American cotton is not adapted to rope drives and, therefore, that it would be necessary to purchase the more expensive Egyptian cotton. The drives mentioned refute this as the English manufacturer giving this information stated that the ropes used were made from a good quality of American yarn and that American yarn gives quite as good service as the Egyptian.

The reason for American yarn being more effective than the Egyptian is that the fiber is not as silky and, therefore, has the necessary resilience. While American fiber is not as strong as the Egyptian, its elasticity saves it under strain and on the whole makes it better for driving purposes.

There is no reasonable limit to the distance power can be transmitted with ropes, either long or short. With suitably arranged idlers, the drives can be carried 200 ft. or more in alleys, or in the open up to 400 or 500 ft. if there is vertical distance enough to take care of the sag and the idlers are properly distributed. For a minimum distance there are instances where rope drives have replaced gears with no change of centers. The drive illustrated in Fig. 6 has operated satisfactorily for a number of years. It is more efficient than gears and eliminates the noise incident to the latter. Of course in a case like this due consideration must be given to the arc of contact on the smaller pulley and the number as well as the size of ropes. This drive would have been impossible with belts, owing to the ratio of speeds as well as the short centers, because the necessary surface could not have been obtained without excessive pulley width. The slip would have been enormous and the belt tension so great as to wear out the belt in a short time. With cotton ropes, owing to the grip of the rope in the grooves, no difficulty has been experienced.

The initial cost of rope drives is less than that of belts, not due to a reduction in the cost of the pulleys, for these are practically equal, but because the cost of rope is much less than that of belts.

The space required for an installation is less with rope than with belts. In a drive of approximately 1000 hp. the ratio of rim widths is 102 for belts to 58 for rope, and for a drive of 250 hp. the ratio is 28 to 17. This would naturally have considerable bearing on the width of a belt tower or on the amount of space taken from a room for driving purposes.

With belts there is a decided difference in rim speed between the driven and driving pulleys, owing, first, to the creep, which is from ½ to 1 per cent. of the speed of the belt and, second, to the slip, which is independent of the creep and may vary from 3 to 5 per cent. in a good drive; even greater in one poorly laid out. With cotton rope creep does not exist because of its elasticity. The rope may stretch on the high-tension side to a certain extent, but its spring or elasticity makes it contract again upon reaching the loose side; if the rope wedges to a certain extent, creep is practically eliminated. Slip cannot exist without rapid deterioration of the rope, so that the speeds of the driving and driven shafts hold a constant ratio. This feature is important as the speed of the machinery varies with the load with belts and thus the production varies, whereas with ropes the speed of the machinery remains constant and the production is constant.

How Much Is Exhaust Steam Worth?

By G. D. Crain, Jr.

This query is suggested by a recent discussion, when a flour miller and a prospective ice manufacturer considered the use of the mill's exhaust steam. The iceman was going to install a machine operating with exhaust steam, and if he could "hook up" with the mill it would save him from buying a boiler.

It looked as though the steam ought to be sold cheap, as what the miller would get out of it would be "velvet." But the price would naturally be affected by the value of the steam to the purchaser, and its value would be indicated, presumably, by the cost of making live steam since that would have to be produced unless the exhaust could be provided. The miller had the steam and the ice manufacturer wanted it, and the balance between the two was so nicely adjusted that the price as finally determined was just about the difference between zero, the previous value of the steam to the miller, and 50 cents, which was the estimated cost of fuel entering into the production of one ton of ice.

The result was that a contract covering a period of years was entered into between the miller and the ice concern, giving the former 25 cents for each ton of ice produced with his steam. The contract was made for a long term to protect the miller and insure him a satisfactory revenue; to protect the iceman and prevent the miller from putting in a machine of his own. Both sides were perfectly satisfied and believed that the exhaust steam was sold at a fair price.

If one were selling exhaust steam for heating, the price would probably be less than if used for manufacturing purposes. For example, the writer knows of a knitting mill operated by motors which needs steam for dyeing, and for this purpose it is valuable. This mill is the neighbor of a woodworking plant, not using its exhaust steam, and the knitter is wondering whether it would be worth while to negotiate with the head of the other factory for the steam now being wasted. He does not, for one reason, because he is afraid the woodworker may suddenly decide that he needs the steam for drying purposes and would cut it off. While a contract would cover this, it might not prevent friction.

A good way to determine the value of exhaust steam is to consider that often live steam is used when exhaust would serve the purpose. To that extent, exhaust steam is worth as much as live. The value depends on the use to which it is to be put, and the maximum market price, apart from the abstract matter of value, is limited by the cost of producing live steam to do the work. Undoubtedly there are many plants now throwing away their exhaust that might find or make a market for it.

Concrete Lining for Steel Bunkers

When building its new plant at Duluth, Minn., the Minnesota Steel Co. also built a large circular steel tank (Fig. 1) for supplying coal to the coke plant. This tank is approximately 55 ft. in diameter, 40 ft. high and holds 2100 tons of coal. For furnishing coal for the gas producers of the openhearth furnaces there are 33 bunkers, each approximately 20 ft. wide, 12 ft. deep and 17 ft. long.

To protect these bunkers from the corrosive action of the coal, it was decided to cover the coke-oven bins with a 5-in. lining and the producer bins with a 2-in. lining of concrete, using a cement gun.

Fig. 2 shows the workmen on the inside of the round tank in the process of depositing the gunite lining. Fig. 3 is a view looking from the top into a line of parabolic bunkers after the work of gunite lining had been finished.

Numerous iron lugs were placed around the inside of the tank. To the lugs vertical rods were wired, and to the rods triangular-mesh wire cloth was secured in horizontal bands. The wire mesh was held approximately $\frac{3}{4}$ in. away from the steel and gunite was then applied. The first layer is shot through the mesh and serves to hold the wire cloth in place, thoroughly covering and protecting the steel plate. The second layer is then applied, bringing it to a total thickness of 5 in. When the work is finished the concrete is monolithic in construction and the surface is smooth and even.

The cement mortar consists of a mixture of portland cement and torpedo sand in the proportion of 1 to 3, mixed dry. It is then shot through a hose by the cement gun having an air pressure of from 40 to 60 lb. Immediately before emerging from the nozzle, the dry mixture is hydrated, the water coming through a separate and smaller hose and being under the control of the operator.

The sand in the first mixture strikes a hard surface, like a steel plate, rebounds, then falls clear of the work to the bottom in the form of clean sand and leaves a coating of cement on the surface. As soon as this coating has attained an appreciable thickness, it acts as a matrix into which subsequent deposits of material embed themselves so that the gunite in contact with the steel plate is clean cement. As a result of this, and of the pressure under which it is applied, the adhesion of the gunite to the flat steel plate runs as high as 500 lb. per sq.in.

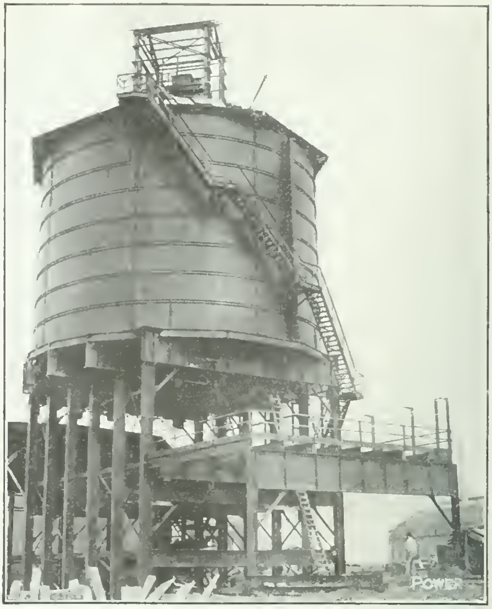


Fig. 1. A 2100-Ton Capacity Coal Bunker Lined with Gunite

This work was executed by the Gun-crete Co., 914 So. Michigan Ave., Chicago, Ill.

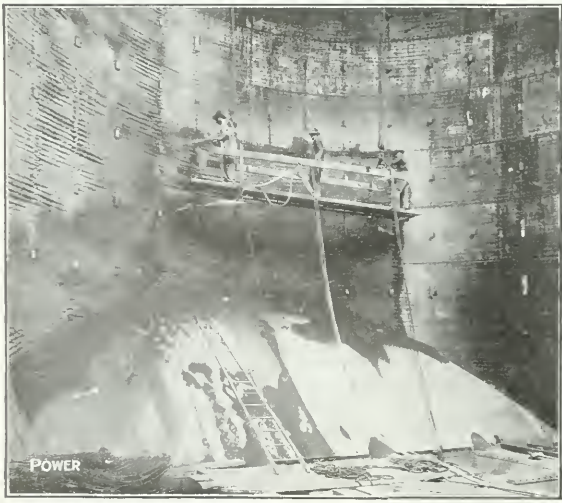


Fig. 2. Process of Lining a Coal Bunker with Gunite

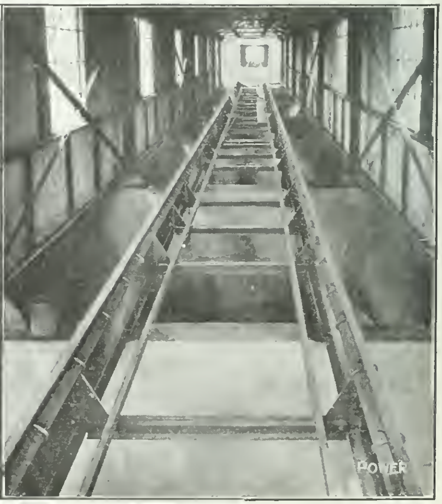


Fig. 3. Finished Interior of Coal Bunker Lined with Gunite

Editorials

High-Pressure Boilers

Since the advent of the steam engine the pressures employed have tended upward. Watt commonly used ten pounds gage and set twenty pounds as the safe limit. Years later Corliss considered a pressure above sixty pounds as unsafe, and at the time it probably was. Such men as Thurston and others prominent in the field realized the advantages of high pressure and it was not long before stronger materials and better designs allowed a considerable advance in this direction. In present-day practice one hundred pounds is conservative even for small plants, two hundred pounds is not uncommon in large generating stations and in marine service water-tube boilers have carried a pressure as high as three hundred and seventy-five pounds.

It is generally conceded that economy increases with the pressure and at a faster rate than would obtain by superheating the steam, although the latter is of importance in reducing initial condensation and in turbines the drag and wear resulting from wet steam. This being the case, practice might be improved by bettering the facilities at hand to safely generate high-pressure steam and perfecting prime movers to utilize this steam to advantage. For the latter, available lubricants and materials of construction limit the working temperature to about six hundred degrees. A pressure of six hundred pounds falls considerably below this limit and might be used in heavily constructed engines having balanced poppet valves or in turbines especially made for the pressure. There is no question that higher pressures pave the way for gains in economy and make possible greater concentration of the power plant. Attempts to continue the general advance in pressure, then, are well worth while, and the effort described on other pages of this issue should be received with interest.

The boiler is of the wet-tube variety and as a consequence does not possess the nonscaling advantage of the flash boiler. In every water-tube boiler using water which has not been previously treated or distilled, scale is sure to form, and in the greatest quantity at the point where the circulation is least active. In the average horizontal water-tube boiler the tubes just above the center of the bank fill up rapidly, and in the type of boiler under discussion much the same action might be expected. With no special provision for inspection or openings through which the scale might be attacked directly, a boiler is under a serious handicap, and this appears to be the weak point of the present design. It is hardly safe to depend on mechanical vibration imparted from the outside or the action of a light fire on dry tubes. Some scale could be removed in this way, but a more positive method is preferable.

It is claimed that the boiler was built to demonstrate the principles advanced and that the construction can be varied to suit requirements. It would be possible to continue the bronze screw plugs, shown on the rear header opposite the two bottom tubes, up to the top if necessary. This would give a direct opening to each tube, permitting inspection and the use of a positive scale remover. Much of the trouble caused by scale could, of course, be obviated by using distilled water in the boiler or by previously treating the feed. The advantages from the higher pressure would no doubt warrant this extra trouble and expense.

Another apparent difficulty would be the regulation of a coal fire to the varying demands upon a boiler with so little heat-storing capacity. With a good bed of fuel burning briskly to carry the normal load on the boiler, it would seem impossible to dampen its effect immediately upon a sudden falling off of the load. Tests conducted to settle this point showed a rise in pressure of only fifteen pounds. Considering the large factor of safety, this small increase is negligible. It would be perfectly safe to set the safety valve above the working pressure and allow whatever margin was necessary to prevent waste of steam.

As stated in the article, the sections can be easily removed for repairs. The repairs, however, require the use of a welding outfit and an operator capable of using it. The alternative is to return the damaged section to the shop, first replacing it by a new element held in reserve. Keeping a number of these sections on hand lessens the necessity for reserve capacity in extra boilers. This is one of the arguments presented in favor of the boiler and it is worth considering.

⁂

Safety First in the Power Plant

For more than thirty years Power has been striving for legislation which should put some safeguard around the design, construction, installation and use of steam-generating and using apparatus.

There is no industrial country which has so little legislation of this kind as the United States—and none which has so many boiler explosions.

In all but a few states and municipalities the design and construction of a boiler are left to the boiler maker. If they are done with intelligence and integrity it is because of the boiler maker's regard for his reputation.

There is nothing beyond his honest craftsmanship or the fear of disclosure to prevent him from using bargain material or money-saving but risky methods in meeting competition or making an extra profit.

There is nothing to prevent a user from putting a boiler into service for which it is not designed nor fitted; from putting second-hand junk under dangerous pressure; from keeping boilers at work after they have reached the age and condition of retirement; from putting boilers and engines in charge of men who do not know enough about them to handle them safely, especially in emergencies. There is nothing to require the user to provide his boilers and engines and their surroundings with the appliances and fittings and conditions, intelligently installed and maintained, which are necessary for their safe operation.

As a consequence there are, under sidewalks and in buildings of all kinds where hundreds of people pass and congregate, boilers more dangerous than dynamite cartridges, in charge of men of the kind who will do the arduous work of keeping them running for the least money.

And as a consequence, there were last year reported in our tabular list 501 boiler accidents, causing the death of 171 and the injury of 387. The greatest number to lose their lives in a single explosion was nine and those injured (not in the same explosion) in one explosion was thirty-two. An estimate of the monetary loss was given only in 120 cases, but the total for this number was approximately $213,000, or an average of $1775. The greatest loss reported was $40,000.

Efforts for corrective legislation have been persistently, and for the most part successfully, opposed by the large users of boilers and employers of engineers; the railroads, the public-service corporations, manufacturing interests; and by engineers who did not feel sufficiently sure of their mastery of their business to submit with confidence to an examination. The employers see in it a menace of restriction in the number of available engineers and boiler attendants which may be abused by the labor organizations, or the specter of a new public official to be kept in good and complacent humor. The engineers, overlooking the fact that the state can go no further than to insist that the man in charge of a steam plant shall be a *safe* man for the position, are terrified by the accounts of examinations given by those who exaggerate their difficulty to magnify their prowess in passing them or to excuse their failure to get through.

A proper law, intelligently administered, will be free from both these evils, and the efforts of the opponents should be directed rather to forestalling these abuses than to opposing legitimate and necessary safeguards to the public safety from apprehension that their possible abuse may lead to their personal inconvenience or loss.

The effort has now extended to a wider and higher plane. A committee of the American Society of Mechanical Engineers, the professional organization best equipped to deal with the subject, presented at the recent meeting of that society a code of boiler rules and specifications which embodies the results of months of study and discussion by all classes interested, from the steel makers to the operating engineers who run the boilers. The boiler makers are organized for the purpose of urging the adoption of these rules by all the states, that they may be relieved from the difficulties occasioned by conflicting laws and that their product may be standardized the country over. It is hoped and expected that every state in the union will enact a law requiring the inspection of boilers and the examination and licensing of engineers, either by an existing department or by a department created for the purpose, and that the code of the American Society of Mechanical Engineers will be universally adopted by those having the administration of such laws in charge. There should then be a national organization of the members of such boards who, in annual convention, would discuss the problems of their administration and desirable additions to or modifications of the rules, to the end that such changes should be general and uniformity maintained. The board in each state should be directed to investigate and report upon every serious accident to a boiler or other pressure vessel occurring in that state, which would lead to a thorough and intelligent census of such accidents and an analysis of their causes which would indicate the modifications of the code most needed.

It is the most pronounced single demonstration of the Safety First movement in the industrial field and we hope to see it make more progress during the coming year than it has in all the years that have gone before.

Engineering at Sargent's Wharf, Boston

The series of articles beginning in this issue and describing the equipment and operating methods in what is, we believe, the largest refrigeration system in the world, that of the Quincy Market Cold Storage & Warehouse Co., Boston, treats of the unusual practice and design as found in the company's chief station, the Sargent's Wharf plant on Eastern Ave. The refrigeration system embodies two large stations, seventeen large warehouses, and a street system having approximately six miles of piping and supplying eight hundred separate services.

Boston is one of the greatest market places in the world, and millions of dollars' worth of the produce coming into that city is refrigerated by this company, both in its own warehouses and by cold brine served through its street system as water is distributed to a city from a reservoir. Much of the service is sold on a guarantee that the temperature will not vary more than one degree. It is important to the value of all the stored goods that the service be not interrupted. If the load of a light or power station is dropped it can be picked up where it was dropped, but if this refrigeration load is interrupted, the temperature continues to so increase that perhaps by the time the service is resumed, the temperature rise is such as to require hours to get it back to normal.

The nature of the service explains certain peculiarities of design and operating practice, at first thought seemingly extreme. Every feature of design, every move in operating, must be thought out and executed to the end that unintentional interruption will be only remotely possible. An idea of the importance of uninterrupted service may be had from the statement that at present one-hundred and fifty million dollars' worth of perishable produce is refrigerated by one compressor.

In this plant, one finds by far the largest ammonia compressor ever built, it being of 1000 tons capacity at a speed of sixty-five revolutions per minute, but its normal speed is seventy-five, at which it is capable of developing approximately fifteen hundred tons. The articles treat thoroughly of the design of this machine. The amount of refrigerated brine pumped daily in hot weather is greater than the water consumption of many a large city. The brine-pumping engines run at exceptionally fast speeds. Turbo-generators furnish light and power for the station and for Boston's great meat clearing house, Clinton Market.

To rebuild by the aid of the plant's own crew worn and antiquated equipment, modernize it, thus carrying a high maintenance charge, but practically none for depreciation or obsolescence, is one of the many unusual practices in the plant. The articles are not in the nature of mere plant description, but rather treat of the details of all the important engineering practice as found in this unusually well conducted system.

Correspondence

Comment on Diagrams

Referring to Mr. McNamm's indicator diagrams from the high-pressure cylinder of an 18 and 32x24-in. condensing engine, published in the Nov. 3 issue, I submit the following:

The trouble is evidently caused by the eccentric slipping on the shaft, reducing the angle of advance and making all the events late.

The head-end diagram shows that the admission line is at the right-hand side instead of at the left, and therefore it will be seen that admission does not occur until about 25 per cent. of the stroke has been completed. During that time the pressure drops because steam is being drawn from the receiver by the low-pressure cylinder. The admission line inclines to the left because the piston is moving rapidly and cutoff is delayed until about 80 per cent. of the forward stroke has been completed. Expansion is not completed at the dead center, therefore the steam is compressed until release takes place at about 25 per cent. of the return stroke and the pressure again drops to that of the receiver.

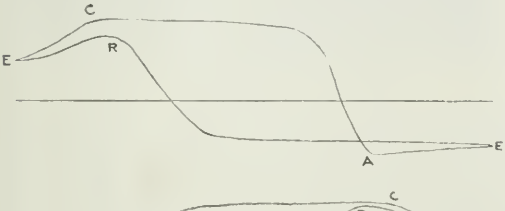
It will be noted that admission on the crank-end diagram is at the left-hand side and that it shows the same general characteristics as the head-end diagram.

The pound mentioned was caused by the abrupt reversal of pressures occurring near the point of release.

E. H. Sawers.

Buffalo, N. Y.

I offer the following: The receiver pressure is too low, being below the atmospheric line. The valve action is late for all events. Admission *A* is at about one-quarter stroke in the head end and one-fifth stroke in the crank end. The expansion line extends from *C*, where cutoff occurs, to the end of the stroke *E*. As the exhaust port does not open until the piston travels about one-half to one-fifth of the return stroke, the steam is compressed for this period instead of being exhausted into the receiver. From *E* to *R*—that is, from the end of the stroke to the point of release, which should be the exhaust line—the line travels nearly parallel with the expansion line *CE*, but it is slightly lower on account of the drop in pressure due to cylinder condensation.



Diagrams Taken by Mr. McNamm

The same thing occurs, and for the same reason, from *E* to *A*, the end of the stroke to the point of admission. The heavy pounding when passing the center is, of course, due to lack of compression. The compression from *E* to *R* takes place at the beginning of the stroke and should therefore not be confounded with the compression at the end of the stroke.

The remedy lies in advancing the eccentric until proper admission is obtained.

Victor Bonn.

New York City.

*

Interesting Cylinder Failure

I quote Mr. McLaren's statement in the Nov. 3 issue: "With the engine running forward and the valve-gear in the forward position, I do not see how water could be pumped, assuming that the piston is traveling toward the head end and that the head-end exhaust valve is open and the steam valve is closed. Any water which might be in the cylinder would have a chance to escape through the exhaust valve until compression begins."

I call Mr. McLaren's attention to the fact that while normally the receiver pressure is low, the terminal pressure might be such that when the engine is started light and steam is admitted into the receiver through a bypass, or, due to a sudden decrease of load, when the steam in the cylinder would be expanded below the receiver pressure, water that might have accumulated in the receiver would be pumped into the cylinder and probably cause damage.

Victor Bonn.

New York City.

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Failure of Concrete Dam

The article in the Oct. 27 issue, page 622, describing the failure of a concrete dam at Marble Rock, Iowa, was interesting. In the fall of 1912 I was asked to go there and confer with those interested in the hydro-electric power project for Marble Rock. I strongly advised that the hydro-electric project be abandoned in view of the character of the foundation, etc., and that a small steam or oil-engine plant be installed at a much lower first cost, as the saving in fixed charges would easily offset the increased operating expense.

If, however, they decided to have a hydraulic plant, I suggested that the dam be built at a point three or four miles down the river where a suitable foundation was available. Evidently my recommendations (and incidentally my bill for services also) were overlooked, for later some contractor furnishing engineering services free installed a hydraulic plant for the town.

With the $15,000 loss, the economic loss to the community or state still remains. It is not often that bad engineering is so quickly and thoroughly shown up as in this case. This instance should be brought to the attention of managers of power plants and industrial properties of all kinds.

Much dangerous construction is going on, not to speak of those numerous instances where thousands of dollars are wasted because those in charge of the work lack the proper experience and are unwilling to pay for the services of competent engineers.

J. C. Lathrop.

Cleveland, Ohio.

⁂

Home-Made Feed Heater

In an account of a home-made feed heater in the issue of Oct. 6, p. 502, together with some data as to results, S. J. Robinson claims to have secured a high rate of heat transfer per foot of heating surface.

The weight of water heated per hour is given as 34,550 lb. raised from 110* to 200 deg. F., which absorbs 3,105,000 B.t.u. Assuming that steam at atmospheric pressure or slightly above is used, the heat (latent) available per pound of steam would be about 970.4 B.t.u., and at this rate the heater would have to have approximately

$$\frac{3,105,000}{970.4} = 3199.7\ lb.$$

of steam per hour passing through and rendering up all its latent heat, which would be unlikely to occur.

Furthermore, from the drawing there appear to be 17 tubes, which would give the total heating surface of about 14.5 sq.ft., requiring a heat transfer per square foot per hour of over 230,000 B.t.u.; this is entirely too high. Even with ten times the heating surface the heat flow would be phenomenal. Roughly, the heating surface necessary to deal with the given weight of water based on 15 lb. of steam condensed per square foot of effective surface per hour would be 230 sq.ft.

E. H. Pearce.

Rochdale, England.

⁂

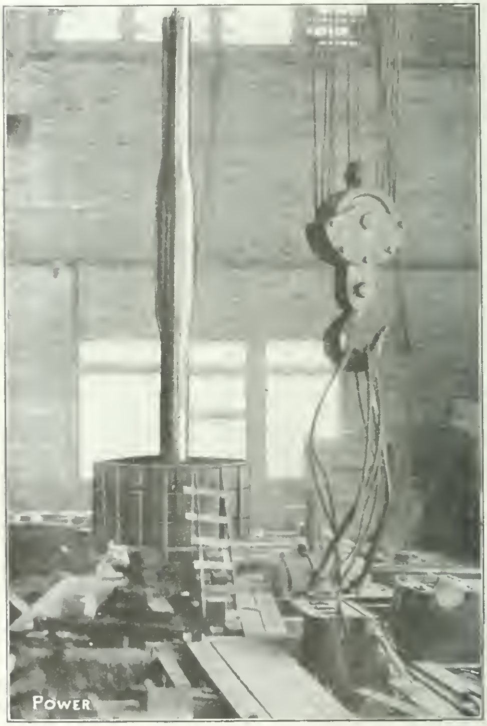
Novel Method of Making a Shrink Fit

In erecting the Drum power plant of the Pacific Gas & Electric Co., the engineers were confronted with an unusual job. The 12,500-kw. generators are of the revolving-field type, each driven by two 10,000-hp. Pelton-Doble waterwheels (one at each end), and the revolving field is mounted on the same shaft between the two bearings. The main shaft is 26 in. diameter and is made of chrome-nickel steel, and hollow. The rotative speed is 360 r.p.m. and may exceed 700 r.p.m. should an accident occur to the governor.

The kinetic energy of the generator is 38,000,000 ft.-lb.; in other words, if the water were suddenly shut off, the flywheel effect of the rotor alone would deliver 20,000 hp. for more than three seconds. It can be seen that a press fit of extraordinary tightness was advisable to prevent either the waterwheel or the generator-rotor disks wrenching loose or slipping under extreme conditions. An allowance of 0.008 in. was specified, and it was estimated that a force of 750 tons would be required. To rig up for such heavy work in an isolated location, without any type of hydraulic press, was the problem before the erectors.

Incidentally, as the rotor was approximately 48 in. in length, the metal of the shaft would in all probability drag and tear, resulting in an unworkmanlike job. For these reasons it was decided to heat the disks for a shrink fit on the shaft. The core of the revolving field was built up of a number of 2-in. disks, so that oil torches or similar methods of heating were deemed inadvisable for fear of distortion due to uneven heating.

Instead, a mammoth caldron, large enough to hold the entire field core, was built, the core placed in it, covered with water, and then heated by fires built about the sides. The water was kept at the boiling point for 48 hr. The core was then lifted by a traveling crane and set on blockings previously arranged. On measuring the hub bore, it was found that the expansion had amounted to 0.02 in., with a temperature rise of 150 deg. F. The shaft was then suspended vertically, lowered into place in the core, and blocked without difficulty.



Shaft in Position to Lower

It is interesting to note that the quantity of heat stored in the metal of the core was so great that it required cooling for 24 hr. before it had shrunk sufficiently to grip the shaft.

This same method was applied to both units, there being three fits on each shaft, or six in all. Two more units of similar size will be installed in the near future and assembled in the same manner.

Walter Swaren.

Hayward, Calif.

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*[In the original letter, a typographical error occurred in the table: it should read (200-110) to agree with the statement in the text.—EDITOR.]

Stresses in Convex Heads

In the July 7 issue appeared a mathematical analysis of the stresses in convex heads by F. G. Gasche, the results of which are rather at variance with opinions previously expressed in these columns.

The resultant formula brings the thickness of convex heads up to three times what is now required as a minimum by existing rules, or, expressed differently, the present minimum factor of safety of 5 becomes 15.2, there being in effect no other difference in the proposed formula of the author as compared with

$$P = \frac{t \times T.S.}{\frac{1}{2} R \times 5}$$

Mr. Gasche's formula is:

$$P = \frac{t \times T.S.}{1.52\ R \times 5}$$

This would undoubtedly make the convex head considerably safer. However, with this proposed higher factor of safety goes the recommendation that the flange turn must be of as small a radius as is practically possible to make it, although a sharp corner must be avoided. It is held presumably that the tangents of the spherical part of the head should run as closely to the point O', Fig. 1, as possible, so that the lever-arm l_1 and consequently the moment Tl_1 will be reduced to a minimum. This is also in line with the vital conclusion of the analysis that the outer skin of the flange turn at A is subject to tension and the inside at B to compressive strains. It is peculiar how a purely theoretical analysis may sometimes lead to just the opposite of what one should judge from appearances actually takes place.

In Mr. Gasche's analysis, although the mathematics seem to have been worked out carefully, it would appear that the basic assumptions on which they rest are not correct.

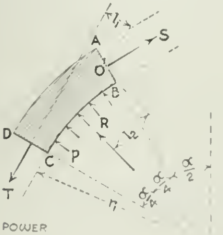


FIG 1

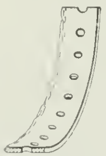


FIG.2

In Fig. 2 is represented part of a flange ring taken from a boiler where the dished sheet originally forming one piece with the ring had blown out. The many short lines running along the edge of the fracture are little cracks of varying magnitudes, while the outer skin of the flange turn along the main line of fracture is unbroken and looks smooth except for a little surface rust. From this, one would be led to believe that the metal on the inner skin was under very high tension from the time of the installation of the dished head until the final rupture occurred; at any rate, one would not expect compression at this point, while the appearance of the outer skin of the flange turn suggests no tension except at the instant of rupture. It has been found also in several cases where convex heads have failed that the heads in the adjacent boilers of the same age and construction had cracks on the inside of the turn of the flange working their way from the inside toward the outside of the flange fillet. Yet Mr. Gasche's analysis tends to show that the opposite should be expected.

First of all, the deflection of the dished part of the head under pressure load is entirely left out of the deductions by simply assuming that a purely spherical tension at the circumference is all one need expect. This wrong assumption is as old as the convex head itself and appears to die very hard, it having been stubbornly adhered to for many years by men prominent in the boiler industry, although it has never been conclusively shown to have any foundation in fact.

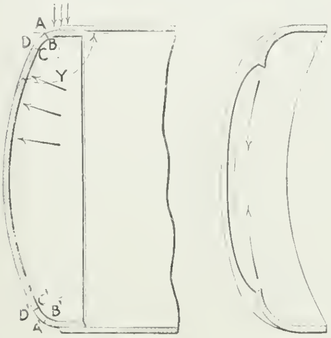


FIG.3

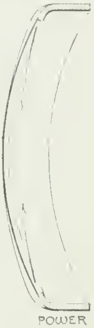


FIG.4

Furthermore, the accuracy of the deductions appears to suffer from the fact that the author treats the lever arms l_1 and l_2 (Fig. 1) as beams with free ends, which, of course, is not actually the case in a boiler head. If argued from the standpoint of pure tension strain in the dished part of the head, the moment Tl_1 about the center O' would be opposed by a resistance against crushing in the dished part, radially from the center, which crushing resistance has not been taken into account in the analysis. Likewise, the moment Rl_2 is not opposed by merely the resistance against bending of the plate section AB, but also by the connection formed by the dished part between two diametrically opposed elements such as $ABCD$ and $A'B'C'D'$ (Fig. 3), as well as by the cohesion between the sides of the adjacent elements, because of the fact that the supposed free ends of the elements form a ring which would be subject to a stretching strain, in case the lever arm l_2 should tend to move outward. Neither of the two latter resistances has been taken into account.

It may thus be safely concluded that by the analysis here criticized, the point that the support of large spherical heads should not depend on fillets of large radius has not been conclusively proved.

The fact that the dished portion of a convex boiler head has a tendency to seek relief from stress by deflection should not need any argument. A flat, round boiler end under pressure may be properly considered as a form of beam supported all around the edges and deflection is naturally expected in such a beam similar to that in any uniformly loaded beams supported at the ends, and there is no reason to assume that such a round uniformly loaded plate should not be subject to similar deflection, as soon as it has been slightly dished. It must be admitted, however, that the degree of deflection becomes less the deeper a convex head is dished.

The stress in the turn of the flange then apparently depends on two major considerations: the flexing of the dished part and the yield toward collapse of the ring to which the dished portion is attached. These two actions cause the angle *Y* in Fig. 3 to become larger, which produces a bending stress in the turn of the flange, the magnitude of which depends on the amount of flexure and collapse respectively, the amount of collapse probably in no case amounting to much.

Neither on the flexure of round plates under uniform load, supported around the edges, nor on the collapse of cylindrical forms have ever been produced mathematical conclusions that adequately cover these problems to such extent that tests will completely bear out their correctness. Such formulas as are in use for either of these problems are mostly based on empirical averaging of practical results, the well known Nichol's rule for boiler ends and Fairbairn's formula for cylinders subject to collapsing pressure being the most prominent and frequently quoted.

In the case of the convex head, offering a combination of these two problems, it would seem almost hopeless to search for an adequate solution by mathematical conjecturing.

Instead, the admirable work done so far with extensometers would seem to point to the only reliable way of settling the question as to whether the flange fillet of convex heads should be as small as possible or of ample curvature. Meanwhile, the contention that a good-sized fillet radius will make conditions better than with an abruptly turned flange (in which a sharp corner has been avoided), is based on the theory that the bending stresses will be distributed over a wider range of stressed area with the former, whereas, with the latter, the stress will be localized in a very narrow range. In this connection, it should also be remembered that the more abruptly a plate is flanged, the greater will be the molecular disturbance due to the flanging process in the steel of the flange heel, which is the very place at which the maximum stresses occur when a convex head is subjected to internal pressure.

Finally, the simple requirement, mentioned by Mr. Gasche, that circular riveted seams at the ends of cylindrical drums should be as near to the tangents of the spherical shell as it is structurally possible to place them, if such a requirement really exists, does not suffer any great violation by increasing the radius of the flange fillet. The idea of this simple requirement is that the overhang between the point of support and point of load should be as short as possible. Considering, however, that in the case of a series of overhanging beams being formed into a ring, such as the flange ring under discussion, not much dependence need be placed on the resistance against bending of the beams individually, since the combined structure of the beams collectively has resistance against collapsing.

In Fig. 4 are shown two flange rings with the dished part of the head omitted. It would appear that the one having the biggest radius of flange turn is a stronger ring against collapsing than the one of minimum radius flange, so that from this point of view the size of radius need not be restricted; in fact, conditions would be better in this regard with the larger fillet radius.

H. J. Vander Eb.

Hartford, Conn.

Repairing Leaks and Breaks

I have found the following repairs successful: A 4-in cast-iron pipe broke apart under a building foundation. To have the water on again as soon as possible, I used the clamp *A*, 6 in. wide and $\frac{1}{4}$ in. thick (Figs. 1 and 2), with sheet-rubber packing wrapped around the pipe, and two pieces of sheet copper *D* and D_1 6 in. wide, where the edges of the clamp came together. This job was done seven years ago and is still satisfactory.

Another 6-in. cast-iron water pipe had a 15-in. crack, Fig. 3. A piece of $\frac{1}{4}$-in. iron 4 in. wide formed to the shape of the pipe, with sheet rubber placed under it, was clamped over the break, Fig. 4. This has also proved successful.

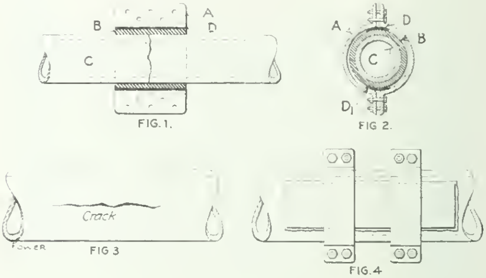


FIG. 1. FIG 2. FIG 3 FIG. 4

Broken Pipes Clamped

A 3-in. steam pipe leaked at the flanges because the threaded ends were badly corroded. A copper sleeve and a 5-in. pipe 8 in. long were slipped over the opening after the flanges were removed, Fig. 5. The space between the outside of the 3-in. pipe and the inside of the 5-in. pipe was then filled with Smooth-On, iron, elastic and power cement mixed. Heat from a blow-torch was then applied for half an hour and in two hours steam was turned on.

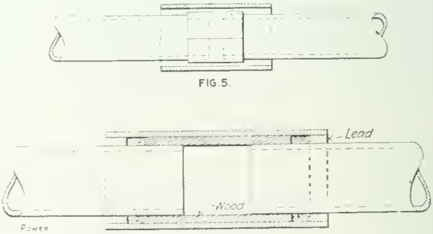


FIG. 5. FIG 6.

Pipe Ends Joined with Sleeves

In extending a cast-iron water main it was found that what should have been the connecting length was a foot short and there was no more pipe of the same size on hand. Instead of sending to the city for a pipe and sleeve, one of the men went into the workshop and in a few minutes turned out a wooden sleeve 16 in. long to fit over the pipe. Next a 20-in. piece of larger pipe was cut and placed over the pipe ends and the wooden sleeve, Fig. 6. The joint was then run with lead in the usual way.

James E. Noble.

Toronto, Ont.

Inquiries of General Interest

Action of Molten Iron in Solidifying—What is the behavior of molten cast iron upon cooling; does it not expand in solidifying?

F. H.

Most cast irons exhibit the phenomenon of expanding immediately after being poured in the mold and during the first process of solidifying, and of then contracting during a continuance of the process and while cooling.

Place for Obtaining Sample of Flue Gas—For boiler flue-gas analysis, at what point should the sample be taken?

G. B.

Preferably at a point where the gases are just leaving the boiler—i.e., in the case of a water-tube boiler the sample should be taken from the last pass of the furnace gases, and in that of a fire-tube boiler it should be taken from the connection between the boiler and the breeching.

Behavior of Cast-Iron Fittings—What effect has superheated steam on cast-iron fittings?

A. R.

Gray cast-iron fittings show a tendency to crack and to assume stretch when employed on superheated or high-pressure steam systems. The cracks, although hairlike at first, frequently widen from continued use, allowing enough steam to escape to make their presence noticeable.

Heat Liberated by Flue Gases—How much heat will be liberated from 20,000 lb. of flue gas reduced from 650 to 300 deg. F.?

E. R. H.

The average specific heat of flue gases is about 0.25. Hence, the liberation of heat from 20,000 lb. of flue gas in undergoing a drop in temperature of

$$650 - 300 = 350 \text{ deg. F.}$$

would be

$$350 \times 0.25 \times 20{,}000 = 1{,}750{,}000 \text{ B.t.u.}$$

Increasing Feed Temperature at Expense of Back-Pressure—In case an exhaust steam feed-water heater raises the temperature from 40 to 200 deg. F. by use of 2½-lb. exhaust back pressure on a noncondensing engine, would it pay to throttle the exhaust sufficiently to raise the feed-water temperature to 210 deg. F.?

G. F. T.

Under ordinary conditions it would not be economical to obtain such an increase in temperature of feed at the expense of increased back pressure, as the gain in heat of feed water could not compensate for the additional steam consumption of the engine for development of the same mean effective pressure.

Corrosion and Protection of Busbars—What is the whitish coating formed on copper busbars when exposed to coal gas from passing railway locomotives, and how can such deposits be removed and prevented?

L. S.

Since the busbars are exposed to coal gas, and probably also to moisture, the copper is attacked by sulphurous acid forming a white sulphate. The deposit can be removed by scraping; or perhaps moistening the busbars with a very dilute sulphuric acid, all traces of which should be removed by rubbing down the busbars with waste moistened in clean water. To prevent further chemical action the busbars, after being thoroughly cleaned, should be lacquered.

Raising Liquor by Air-Jet Lift—For transferring a warm liquor from one tank to another, a steam siphon is found to be objectionable, as the condensed steam mingles with the liquor. What type of air pump or other air appliance can be used, the liquor having a density of about the same as that of sea water and the tanks being each 13 ft. in diameter by 8 ft. deep?

K. P. H.

Assuming that aeration of the liquor is not objectionable and that a supply of compressed air is available, a convenient method of transferring the liquor from one tank to another would be by an air-jet lift, which should be placed below the lowest level of the liquor which is to be elevated.

Placing Patch on Horizontal Return-Tubular Boiler—Should patches on the shell of a horizontal return-tubular boiler be placed on the inside or the outside of the boiler?

C. M.

Generally speaking, it is better to place a patch on the inside, as in putting on a patch the riveting and calking tend to flatten the curvature of the shell, and when the patch is placed on the outside the calking is more likely to become opened by the effort of the shell to assume a circular form when under pressure. Patches below the water-line always should be placed on the inside, otherwise a pocket of a depth equal to the thickness of the shell plate is formed inside and soon becomes filled with sediment which may cause the patch to become burned.

Detecting Grounded Bar of Stator—What method may be employed for detecting a grounded coil of the stator of a three-phase induction motor without removing the rotor?

M. F. K.

With any source of direct current, preferably 110 volts, connect one side to the motor frame and the other side to one lead from a lamp socket. Untape the stator windings where the phases join and with the other lead from the lamp, test each phase. The one grounded will cause the lamp to light. Having determined this, untape several groups of coils and in this way find which group the trouble is in and similarly locate individual coils which may be grounded. Also, a voltmeter may be used for this purpose, or a telephone receiver with a low voltage current, as explained in connection with direct-current armatures in the Nov. 3 issue of "Power." Also see "Short Circuits and Grounds in Field Coils," Sept. 1 issue of "Power."

What Becomes of the Heat in the Fuel—What becomes of the heat which is supplied in the form of fuel to the boiler furnace of a noncondensing steam-power plant?

J. S.

The heat losses and utilization of the heat in the coal will vary with different plants and different conditions in the same plant. In the average steam-power plant, using a noncondensing engine and exhaust steam feed-water heater, the heat of the fuel supplied to the boiler furnace is distributed in about the following proportions:

	Per Cent.
Lost through the grates	1.5
Lost by radiation from boiler and setting	5.5
Lost in chimney gases and incomplete combustion	25.0
Lost by radiation from steam pipes	1.5
Delivered to pump	1.5
Lost by radiation from engine	2.0
Lost in engine friction	1.0
Lost in engine exhaust	55.0
Utilized as power delivered by engine	9.0
Total	100.0

Evaporation Under Stated Conditions—With coal showing 14,000 B.t.u. per lb., an efficiency of boiler and grates of 68 per cent. and a feed-water temperature of 200 deg. F., how many pounds of water per pound of coal would be evaporated into steam at 150 lb. gage pressure?

M. G.

There would be 68 per cent. of 14,000 or 9520 B.t.u. available from each pound of coal. Gage pressure of 150 lb. per sq.in. would be equal to about 150 + 15, or 165 lb. absolute, and, according to the Marks and Davis steam tables, a pound of dry saturated steam at that pressure has a total heat of 1195 B.t.u. above 32 deg. F. With the feed water at 200 deg. F.—i.e., 200 − 32, or 168 deg. F. above 32 deg. F.—then, for conversion into steam of the stated pressure, each pound of water would receive

$$1195 - 168 = 1027 \text{ B.t.u.}$$

and with 9520 B.t.u. available from each pound of coal, the evaporation under the conditions would be

$$\frac{9520}{1027} = 9.26 \text{ lb.}$$

of water per pound of coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--VIII

Fans and Heaters

Before taking up the design of the heating and ventilating apparatus for the different buildings, it may be well to give a small amount of general data relating to the more important parts of the equipment used for this purpose. The centrifugal fan with steel housing is the type almost universally used for this class of work. It is not only compact and self-contained, but produces a higher pressure than a disk fan under similar conditions, and is therefore better fitted to overcome the resistance caused by long runs of piping with more or less frequent bends and offsets. Casings may be had with either one or more outlets arranged to discharge the air at any angle desired, thus lending themselves readily to installation in a variety of locations.

While the relative proportions of wheel and casing vary somewhat with different manufacturers, in a number of standard makes examined, the width of wheel at the center was found to be about 0.52 of the diameter. Although in some makes the outlet is given a greater height than width, it is more customary to make it square with a dimension each way about 2 in. greater than the width of the wheel. These dimensions are especially noted because they are assumed in the computations and tables which follow.

While the efficiency of a fan increases up to a peripheral velocity of about 8000 ft. per min., it should not exceed about 3500, where quietness of operation is required, as in schools, churches, etc. For shops and factories, where a certain amount of noise is not objectionable, the peripheral velocity may be increased to 5000 ft. or more with good results.

In general, the volume of air delivered by a fan varies directly as the speed, and the power as the cube of the speed. That is, doubling the speed will double its capacity, but will require eight times the power to drive it. This increase in power applies only to ideal cases, and does not take into account the efficiency of the fan. However, the power increases much more rapidly than the volume of air delivered, even under practical conditions, and should always be borne in mind when the matter of speeding up a fan to increase its capacity is under consideration.

Under the conditions of hot-blast heating as applied to machine shops and foundries, the capacity of a centrifugal fan is given approximately by the formula

$$V = 0.43 \times C \times R \times O$$

in which

V = Volume of air moved in cubic feet per minute;
C = Circumference of fan wheel in feet;
R = Revolutions per minute;
O = Area of outlet in square feet.

Table 1 gives data for use with the above formula.

TABLE 1—FAN DIMENSIONS

Diameter of Fan Wheel, Over All, Ft.	Circumference of Fan Wheel (C), Ft.	Area of Outlet (O), Sq.Ft.
3	9.4	2.9
3½	11.0	3.9
4	12.5	5.0
4½	14.1	6.2
5	15.7	7.6
5½	17.3	9.1
6	18.8	10.7
7	22.0	14.4
8	25.1	18.6
9	28.3	23.4
10	31.4	28.7

Table 2 has been computed by the formula, for fans having speeds of approximately 5000 ft. per min. peripheral velocity, and also gives the brake-horsepower of motor for driving them at these speeds.

TABLE 2—FAN SPEED, DELIVERY AND HORSEPOWER REQUIRED

Dia. of Fan, Ft.	Speed, R.p.m.	Volume Delivered, in Cu.Ft. per Min.	B.Hp. of Motor for Driving Fan
3	530	5,400	5
3½	450	8,500	6
4	400	10,400	7
4½	360	13,400	8
5	320	16,300	10
5½	300	20,100	13
6	270	23,200	15
7	230	31,300	18
8	200	40,800	24
9	180	51,300	32
10	160	62,000	40

In using Table 2 select the size which, at the given speed, delivers the volume of air nearest to that required, and make the necessary change in speed.

Example—What size and speed of fan will be required to deliver 38,000 cu.ft. of air per minute under the conditions of shop or factory heating, and what horsepower of motor will be required for driving it?

From Table 2 an 8-ft. fan at 200 r.p.m. will deliver 40,800 cu.ft., which is the nearest to that required. Therefore, a fan of this size should be used and run at a speed of

$$\frac{38,000}{40,800} \times 200 = 186 \ r.p.m.$$

The change in horsepower is found as follows: While, theoretically, this varies as the cube of the speed, it will be found under actual working conditions, for variations of 50 to 75 r.p.m. either side of the speeds given in the table, that the horsepower varies approximately as the square of the speed. Hence, for any change within these limits, divide the new speed by the old, square the result, and multiply this by the old power taken from the table. In the above example, the old speed is 200, the new speed 186 and the old power from the table, 24. Therefore, at the new speed

$$\left(\frac{186}{200}\right)^2 \times 24 = 20.7 \ hp.$$

will be required.

Practical Application

Having decided upon the method of computing the size of fan and motor, and the approximate speed at which they are to operate, let us apply these to the various buildings of the plant under consideration. Taking up the machine shop first, there are two conditions to fulfill in determining the volume of air to be handled by the fans. First, the volume should be sufficient to carry in the required amount of heat for warming the building, within a normal working range, say between 60 deg. and 140 deg.; and second, the fans must be of sufficient capacity to give to the building three complete air changes per hour in mild weather. The required volume for each should be computed, and the fan capacity made large enough for the greater. Assuming the normal temperature of the building to be 60 deg., and the temperature of the air delivered by the fan 140 deg., which may be taken as average conditions, the rise in temperature will be

$$140 - 60 = 80 \textit{ deg.}$$

In cooling 80 deg. it gives off

$$80 \times \tfrac{1}{55} = 1.4 \textit{ B.t.u.}$$

Therefore, the total heat required per hour for warming divided by 1.4 will give the cubic feet of air to be moved by the fan.

Previous computations have shown that in the case of the machine shop 3,409,000 B.t.u. are required for warming the building in zero weather, hence

$$3{,}409{,}000 \div 1.4 = 2{,}435{,}000 \textit{ cu.ft.}$$

of air must be moved per hour for transmitting the required amount of heat. Computing the volume on the basis of ventilation with three complete air changes per hour, it is found that

$$1{,}760{,}000 \times 3 = 5{,}280{,}000 \textit{ cu.ft.}$$

are required per hour, or

$$5{,}280{,}000 \div 60 = 88{,}000 \textit{ cu.ft. per min.}$$

As this is the larger volume, the fans must be proportioned on this basis. In a building of this size it will be best to use two fans having a capacity of 44,000 cu.ft. each. Table 2 shows that an 8-ft. fan at 200 r.p.m. will deliver 40,800 cu.ft. of air per min. and requires 21 hp. Hence, in the present case two 8-ft. fans will be used, each running at

$$\frac{44{,}000}{40{,}800} \times 200 = 216 \textit{ r.p.m.}$$

and requiring a motor of

$$\left(\frac{216}{200}\right)^2 \times 21 = 28 \textit{ hp.}$$

Taking up the other buildings and rooms to be ventilated, in a similar way, and using data on heat requirements and air supply already computed in a previous article, gives the following:

For the foundry the heat requirements are 1,007,800 B.t.u. per hr. In this case, the normal temperature of the building is only 50 deg. and the heat requirements are divided by

$$90 \times \tfrac{1}{55} = 1.6$$

to get the air volume, which is

$$1{,}007{,}800 \div 1.6 = 629{,}875 \textit{ cu.ft. per hr.}$$

The computed air supply for ventilating purposes in this case is 600,000 cu.ft., so the larger volume will be used, which is

$$629{,}875 \div 60 = 10{,}498 \textit{ cu.ft. per min.}$$

requiring a 4-ft. fan at approximately 400 r.p.m. driven by a 7-hp. motor. This building is to have a vent or discharge fan also of the same capacity.

In the forge shop the heat requirements are 378,840 B.t.u., requiring

$$378{,}840 \div 1.6 = 236{,}775 \textit{ cu.ft.}$$

of air per hour. The computed volume for ventilation was 200,000 cu.ft.

$$236{,}775 \div 60 = 3946 \textit{ cu.ft. per min.}$$

for which a 3-ft. fan at 320 r.p.m. may be used, requiring a 3-hp. motor.

The total air volume for the remaining rooms, which are to be supplied by a single fan, are as follows: Offices, 403,200; toolroom, 268,800; drafting room, 378,000; pattern shop, 252,000. This makes a total of 1,302,000 cu.ft. per hr., or

$$1{,}302{,}000 \div 60 = 21{,}700 \textit{ cu.ft. per min.}$$

A 6-ft. fan at 270 r.p.m. may be used in this case with a 15-hp. motor. This gives a small surplus, which is on the side of safety, the capacity from Table 2 being 23,200 cu.ft. per min.

HEATERS

The heaters used for hot-blast work in shops and foundries are of two general types, those made up of wrought-iron pipe screwed into cast-iron bases or headers, and cast-iron sections of the pin type, designed and connected up for this particular class of work. In designing a heater of this general type, three requirements must be kept in mind: It must be of sufficient depth to give the desired final temperature to the air; it must contain sufficient radiating surface to give off the total amount of heat required for warming and ventilating purposes, and must have sufficient free area between the pipes for the flow of air without producing an excessive velocity.

Both the efficiency and final temperature will vary with the temperature of the entering air, the steam pressure and the velocity of the air through the heater. The efficiency will be increased by increasing the velocity of flow, but the final temperature will be diminished; that is, a larger quantity of air will be heated to a lower temperature in the second case, and while the total heat given off is greater, the air quantity increases more rapidly than the heat quantity, which causes a drop in temperature. Increasing the number of rows of pipe, or depth of heater, with a constant air velocity, increases the final temperature but diminishes the efficiency, because the average difference in temperature between the steam and air is less. Increasing the steam pressure in the heater increases both the final temperature of the air and the efficiency of the heater.

Considerable data have been published in the last two or three years relating to the results obtained from heaters of this type under different conditions. Table 3 has been prepared for the average practice in shop heating, where exhaust steam is utilized in the coils at, or slightly below, atmospheric pressure, and where the air passes through the heater at an average velocity of about 1200 ft. per min. It is also assumed that the temperature of the entering air is zero.

TABLE 3 TEMPERATURES AND HEAT GIVEN OFF

Rows of Pipe Deep	Final Temp. of Air, Deg. F.	B.t.u. Given Off per Sq.Ft. of Heating Surface per Hour
	75	2100
12	80	2000
16	100	1900
20	115	1800
24	130	1700
28	140	1600

The free area through a standard-pipe heater will not vary much from 0.4 of the overall or gross area, and this relation may be used when checking a given heater for maximum velocity.

Table 4, arranged by the writer some years ago, gives approximate dimensions of pipe heaters of standard type and may be used in the design of the heaters in the present plant.

TABLE 4—DIMENSIONS OF STANDARD-PIPE HEATERS

Width of Section, Ft.	Height of Pipes, Ft.	Sq.Ft. of Heating Surface	Width of Section, Ft.	Height of Pipes, Ft.	Sq Ft. of Heating Surface
3	3½	20	5	6½	62
3	4	22	5	7	67
3	4½	25	6	6½	75
3	5	28	6	7	81
4	4½	34	6	7½	87
4	5	38	6	8	92
4	5½	42	7	7½	98
4	6	45	7	8	103
5	5½	52	7	8½	109
5	6	57	7	9	116

The square feet of heating surface given above are for a single row of pipes. When computing the overall dimensions allow one foot in height for the base in addition to the pipes; and the same amount on the width for the supply and return headers.

Taking up the design of the heaters for the machine shop we have the following conditions. Dividing the work equally between two heaters, and assuming two air changes per hour in zero weather, gives the heat quantity to be supplied by each heater under maximum conditions.

In the fourth article of the present series the heat requirements for the machine shop were 3,409,000 B.t.u. per hr. for heating and

$$2 \times 1{,}920{,}000 = 3{,}840{,}000 \textit{ B.t.u.}$$

per hr.-ft. for ventilation. The air volume is 3,520,000 cu.ft. per hr.

The first step is to determine the final temperature to which the air must be raised, in order to find the required depth of heater and the efficiency to be expected. The heat required for ventilation is simply for raising the given volume of air from 0 to 60 deg., the temperature of the room, so does not enter the computation. The problem therefore becomes: Through how many degrees must this volume of air be raised to bring in the B.t.u. required for warming the building? This rise in temperature added to 60 deg. will evidently give the final temperature. The formula for this is

$$T = \frac{55\,H}{V}$$

in which

T = Rise in temperature in degrees;
H = B.t.u. to be given to the entering air per hour;
V = Volume of air, in cu.ft. entering per hour.

Substituting the given quantities in the formula, gives

$$T = \frac{55 \times 3{,}409{,}000}{3{,}520{,}000} = 53$$

from which the final temperature is found to be

$$53 + 60 = 113 \textit{ deg.}$$

Referring to Table 3, this will require a heater 20 pipes deep, and the radiation per square foot of surface per hour will be 1800 B.t.u., which calls for a total heating surface of

$$\frac{3{,}409{,}000 + 3{,}840{,}000}{1800} = 4027$$

or practically 4000 sq.ft., making 2000 sq.ft. in each heater. If the heater is to be 20 pipes deep, each row must contain

$$2000 \div 20 = 100 \textit{ sq.ft.}$$

of heating surface, which from Table 4 corresponds closely to a section 7 ft. wide by 8 ft. high. Checking for velocity, there is a free area of

$$7 \times 8 \times 0.4 = 22.4 \textit{ sq.ft.}$$

The volume of air passing through the heater per minute is

$$\frac{3{,}520{,}000}{60 \times 2} = 29{,}333 \textit{ cu.ft.}$$

which gives a velocity of

$$\frac{29{,}333}{22.4} = 1309 \textit{ ft. per min.}$$

This is within the usual limit of about 1500 ft. per min.

In the foundry the air supply for limiting the temperature of the entering air to 140 deg. was found to be 629,875 cu.ft. per hr., which calls for

$$\frac{629{,}875 \times 140}{55} = 1{,}603{,}318 \textit{ B.t.u.}$$

to raise it from zero to 140 deg. final temperature. The heater should be 28 pipes in depth, and will give off 1600 B.t.u. per sq.ft. It will require

$$1{,}603{,}318 \div 1600 = 1002 \textit{ sq.ft.}$$

of surface, with

$$1002 \div 28 = 36 \textit{ sq.ft.}$$

per section. From Table 4, this corresponds to a 4x5-ft. section, which has a free area of

$$4 \times 5 \times 0.4 = 8 \textit{ sq.ft.}$$

and permits an air velocity of

$$\frac{629{,}875}{60 \times 8} = 1312 \textit{ ft. per min.}$$

This is within the limits.

In like manner the forge shop is found to require a heater 28 pipes deep, made up of 3x3-ft. sections, and containing 400 sq.ft. of surface.

The total air supply for the office wing of the building is 1,302,000 cu.ft. per hr., and is to be raised to 70 deg. in zero weather. This will require a heater 12 pipes deep containing

$$\frac{1{,}302{,}000 \times 70}{55 \times 2000} = 828 \textit{ sq.ft.}$$

of surface. This should be made up of 6x6½-ft. sections to give the required surface and area for air flow. Another article will deal with the arrangement of these fans and heaters together with air distribution, piping details at heaters, etc.

⁂

Blind and Blank Flanges—The words "blind" and "blank" are often erroneously used in connection with flanges. A blind flange is to close the end of a pipe, while a blank flange is not drilled but in all other respects is complete. The words "blank flange" are sometimes used to designate a pipe flange which is not threaded, though this is poor usage.

⁂

A Remarkable Stream—Deschutes River, Oregon, a tributary of the Columbia, is unique. Its natural flow is remarkably constant. In times of so called floods it rises only a few inches, because, for a considerable part of its course it flows through a region of lava and loose volcanic material which act as a huge sponge. The headwaters of the river afford such large and well distributed reservoir sites that the total flow of the river may be utilized both for irrigation and for power. The irrigable lands in the valley aggregate 300,000 to 500,000 acres. Below this area the river flows in a deep Cañon having a fair slope and affording excellent opportunities for power development. A reliable water supply is assured by the return waters from the irrigated areas above, a large part of the water seeping back into the channel, and by the lower tributaries of the river. The United States Geological Survey has just issued a comprehensive report discussing the river's possibilities. The investigations of power resources indicate that after allowing for irrigation, a total of 600,000 hp. may be developed. A copy of the report, which is published as Water-Supply Paper 344, may be obtained free on application to the Director, United States Geological Survey, Washington, D. C.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

This week we'll just jest, jab and josh with Prosperity, all the way down the column. Have a few jumbles with your Uncle Billy!

⁂

Fifteen thousand employees of the Lynn works of the General Electric Co. are now working full time. Three days a week were all they were getting. Prosperity's on the job.

⁂

Hard times and trouble? Not when 75,000 cheerful idiots can warm up to a football match on a cold fall day.

1 Football — 3 Highballs + Enthusiasm = 75,000 Happy Souls.

And old Prosperity went down in his jeans for it!

⁂

Despite the inroads of the typewriter, the fountain-pen industry has trebled in these United States in ten years. Prosperity's pen is mightier than the typewriter. Proof? Give a glimpse at the "Correspondence" pages this week.

⁂

Perhaps your employer will be far more prosperous when you are able to advise him in any contemplated purchase of new equipment. Even now he may be waiting for you to come forward and go to it. Other engineers have been well repaid for this welcome service; why not you, son?

⁂

There is a Prosperity movement on foot to make the 1915 wheat crop a record-breaker. Bully! Here's hoping that our factories and shops, our power plants and our business houses execute a similar foot movement and bust a few records. And—oh, let it be soon!

⁂

A Vermont lad 89 years young has, in the exuberance of his youth, given up smoking. Having had that habit for the past 70 years, he's turned over a new (tobacco) leaf. If any of you 89-year-old engineers think this habit stands in the way of old man Prosperity getting you, give it up. We're going to—when we're 89.

⁂

Why are the operating engineers, the boiler manufacturers, the American Society of Mechanical Engineers working on a standard type of boiler if not for their mutual Prosperity?

⁂

The time is near at hand when the retardation and stagnation of our waterpower resources will give way to healthy development; when the public lands will go to bona fide homeseekers; when our waters will be used for navigation, irrigation and power; when timber will be cut to build homes, schoolhouses and power plants—and then old man Prosperity will be chucking you and I under our chins!

⁂

To cite a few instances, why have we recently built a centrifugal pump with a capacity of 100 million gallons per 24 hr.; a twin-tandem compound geared reversing engine developing 25,000 hp.; a boiler carrying a load of 11,000 kw. per hour; a jet condenser condensing 150,000 lb of steam per hour; a 10,000-hp. turbine weighing a million pounds?

⁂

Because the wonder of yesterday is but a commonplace today; because big business necessitates big developments—because Mister Prosperity needs 'em in his business in order to live up to his name!

⁂

But, shucks! we won't prosper, too, unless we prod ourselves into something like activity—and keep a-prodding' When the good things come our way we've got to be prepared to grab 'em by the coattails and swarm up into the band wagon at the head of the parade. Let's help make the dust, and not straggle along at the tail-end of the procession and be compelled to swallow it. You're hep, ain't you? Sure! Then—

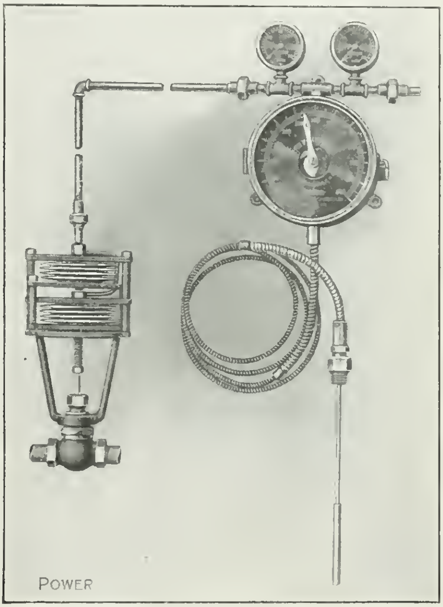
⁂

Hooray for Prosperity'

Foxboro Temperature Regulator

This new controller has three principal parts, the bulb, the controller proper and the diaphragm valve. The bulb may be made of brass, copper or steel, depending upon the chemical action of the liquids or vapors with which it comes in contact. Its size and shape may be made to fit the requirements of the apparatus or room the temperature of which is to be controlled.

The bulb is filled either with liquid, gas or liquid and vapor. The pressure in the bulb, due to the change in the temperature surrounding it, is transmitted to the interior of the controller case through a capillary tube protected by a flexible tubing, as shown in the illustration. The capillary tubing inside the case is connected to a hermetically sealed helical spring; therefore, the pressure in the bulb is transmitted to the spring and gives motion to it.



Foxboro Temperature Regulator

Through proper connections, the helical spring operates a small valve contained in a part of the casting projecting through the top of the controller case. The motion of the spring actuates this valve and allows the pressure or vacuum, depending upon which system is used, to enter the piping at the left of the controller, this piping being connected to the diaphragm valve.

The diaphragm-controlled valve is inserted in the pipe line supplying heat to the device the temperature of which is being controlled and is opened or closed by the action of the diaphragms. The number of diaphragms depends upon the pressure against which the valve operates. Where pressures are over a few pounds the valve is balanced, therefore the number of diaphragms does not become excessive. The diaphragm valve has no rubber parts as it is made of metal: it may be had in sizes up to 12 in.

The small gage at the right of the controller indicates the amount of pressure or vacuum maintained by the supply system: the gage on the left indicates when and how much pressure or vacuum is used to operate the diaphragm valve. The working parts inside the controller case are few and simple.

The recorder is manufactured by the Industrial Instrument Co., Foxboro, Mass.

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Winslow High-Pressure Boiler

SYNOPSIS—A new high-pressure boiler of the wet-tube type designed to operate at pressures up to 600 lb. and 300 deg. of superheat. Virtually it is a water-tube boiler, without drums, made up of removable sections consisting of a number of small tubes welded into headers. Due to small storage of energy and the small tubes, the boiler has a large margin of safety. Advantages claimed are concentration and a higher overall efficiency for the power plant.

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For over four years the Winslow Safety High Pressure Boiler Co., Chicago, Ill., has been experimenting on a high-pressure boiler with the original intention of applying it to automobile truck and tractor service and later to any field requiring steam at high pressure. Essentially it is a water-tube boiler without the drums, made up of a number of individual elements each consisting of a bank of tubes welded into headers. The elements are arranged vertically, and as many as are needed to make up the capacity are placed side by side over the boiler furnace. At the top each element connects with a common steam header and at the bottom with a mud pipe and a tap from the feed-water supply (Fig. 1).

Due to the relatively small tubes employed, it is claimed that pressures up to 2000 lb. can be safely generated, but 600 lb. is about the limit for the lubricants and materials of construction available for the prime mover. This is the highest pressure the company intends to use for power-plant service. As there are no large drums and only small storage of energy, there need be no apprehensions about the safety of the boiler. The rupture of a small tube should not prove serious, and this is about all that could happen in the present design.

Construction of Boiler

Referring to Fig. 1, one of the elements is shown in position, the others being in line behind it. The form of the section and its connection to the steam header A, mud pipe B and the feed pipe C will be apparent. It will be noticed that the tubes are inclined, the front ends being higher than the rear, and proceeding upward the inclination gradually decreases until the top tube is practically horizontal. All of the tubes are slightly bent, so that they may expand considerably under heat without warping out of line. Each section carries a baffle D made of cast iron or steel channels filled with plastic refractory material. The baffles of each section come in contact and

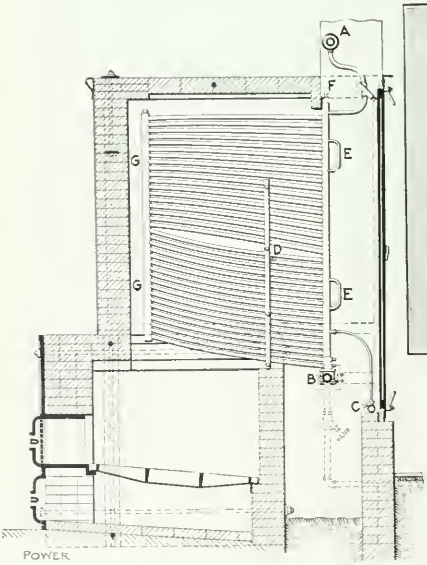
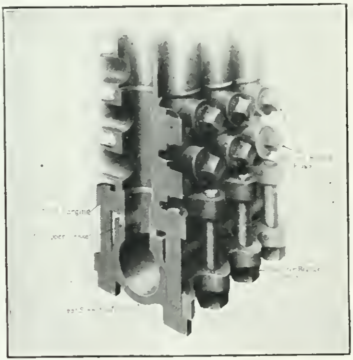


FIG. 1



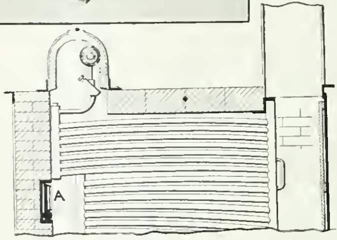


FIG. 3

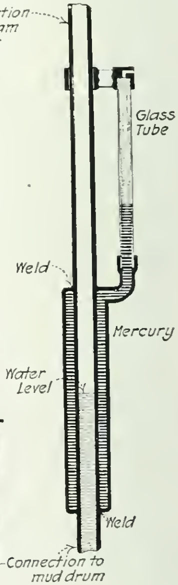


FIG. 4

Fig. 1. Vertical Section through Winslow Boiler. Fig. 2. Lower End of Rear Section Header and Mud Pipe. Fig. 3. Showing Provision Made for High Superheat. Fig. 4. Water-Level Indicator

those on the outside touch the walls of the setting, so that a complete baffle wall is formed, forcing the gases to pass up over the front of the tubes and down at the rear.

From the upper end of each rear section header a steel tube leads to the steam header. This tube is made up in two parts, one welded to each header and both connected to each other by a special joint. The lower end of the rear section header is connected to the mud pipe as indicated in Fig. 2, and opposite the two lower tubes bronze plugs give access for inspection or cleaning. A tap for the feed pipe near the bottom of the rear header is the third connection for each section. These three joints are the only ones which are not welded, and as they are located in the last pass for the gases, the temperature to which they are exposed is comparatively low. The joints are accessible and made with metal-to-metal contact. By breaking these three joints a section can be removed for cleaning or repairs, and the boiler can be maintained in operation without serious inconvenience. The handles *E* are provided to facilitate removal. In putting the sections back in place the forward movement is restricted by the joint at the mud pipe and the angle *F* against which the top of the rear header comes in contact.

Between the front headers and the wall of the setting a small flue space *G* has been provided to lead part of the hot gases from the furnace to the top tubes of each section. This flue is proportioned to give the necessary higher temperatures to the upper tubes for drying and superheating the steam. Where high superheat is desired the upper tubes are made longer and the superheating zone is detached from the zone of water circulation, as shown in Fig. 3. After passing over the superheating tubes the gases unite with the main stream at the top of the baffle and pass downward on their way to the stack over the coldest part of the heating surface. Thus the functions of a boiler, superheater and economizer are combined in one unit.

Due to the high pressures and temperatures, a special water-level indicator is used. It consists of a steel tube surrounded by a steel jacket, the intervening space being filled with mercury. As shown in Fig. 4, a glass tube is fitted into the top of the jacket, to show the level of the mercury. That part of the mercury surrounding steam will absorb more heat than the part exposed to the water. From the average temperature resulting, the mercury will rise to a certain point and thus definitely indicate the water level. The mercury will be high for low water, and *vice versa*. There will be a certain lag in the indication, due to the increment of time necessary to transfer the heat through the metal wall, but this is negligible, as a wide range in water level is permissible without decreasing the safety or the economy of the boiler. When superheated steam is generated a thermometer, usually of the dial form, is used as an additional indicator of the water contents of the boiler.

Action of the Boiler

Reference to Fig. 5 will make clear the action of the boiler. The arrows show the path of the gases, and the circulation is indicated by the different symbols. From the lower tubes the water naturally flows toward the front header, rising in the latter and returning through the upper tubes. The nearer the top, the less the water, until separation is practically complete and only steam is present in the uppermost tubes. The hot gases from the furnace through the front bypass dry this steam and superheat it to a certain degree. As previously mentioned, special provision is made for higher superheat. Due to the rapid circulation from front to rear, much of the suspended matter settles in the mud pipe and is removed through the blowoff.

Cleaning

To clean the tubes inside and out it is proposed to remove the sections and perform the work outside of the boiler. When scale has formed in any of the tubes the usual process of removal consists of mechanical loosening with a copper or pneumatic hammer. The scale is then washed out by inserting in the front header a small tube with an outlet near the end, so that the water can discharge into the boiler tubes. Scale has also been loosened by means of a small wood fire. With the section empty the metal expands faster than the scale and the latter is freed from the surface. Any repairs to the section can be made at the same time, but the use of a standard welding outfit is required.

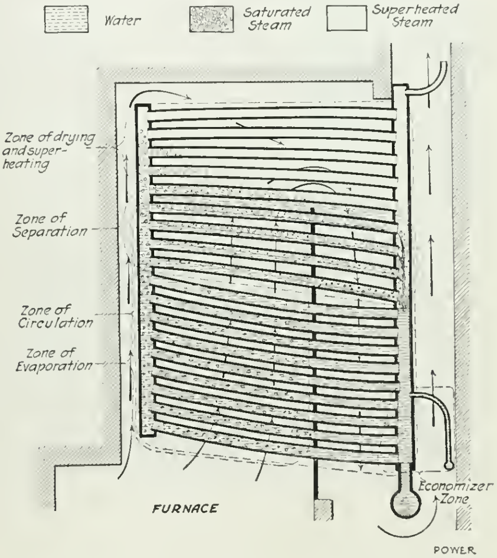


Fig. 5. Sketch Illustrating Action of Boiler

Experimental Boiler

A small boiler has been used for some time on an automobile owned by the company and has given excellent satisfaction. A power boiler has also been set up in the boiler room, and during the past year has been operated at frequent intervals. It is rated at 60 hp. and contains 18 sections 4 ft. long and about 5 ft. high. Each section has thirty-six 1¼-in. tubes, having 0.095-in. walls, welded into 2-in. headers. The total heating surface is 817 sq.ft., or 14 sq.ft. per horsepower of rating. Ordinary flat grates having a surface of 16 sq.ft. are employed. The ratio of heating to grate surface is thus 53 to 1.

The furnace or bottom part of the setting is 8 ft. 3 in. long and 5 ft. 7½ in. wide, making a total of 46.4 sq.ft. of floor space occupied, or 0.77 sq.ft. per horsepower of rating. The upper part of the setting is 4 ft. 2 in. wide. 6 ft. 1½ in. long and the height from the floor to the top of the setting is 11 ft. Front and side views of the boiler are shown in Fig. 6. At the back the large doors giving access to the sections will be noticed, and at the front and side of the setting the numerous inspection doors.

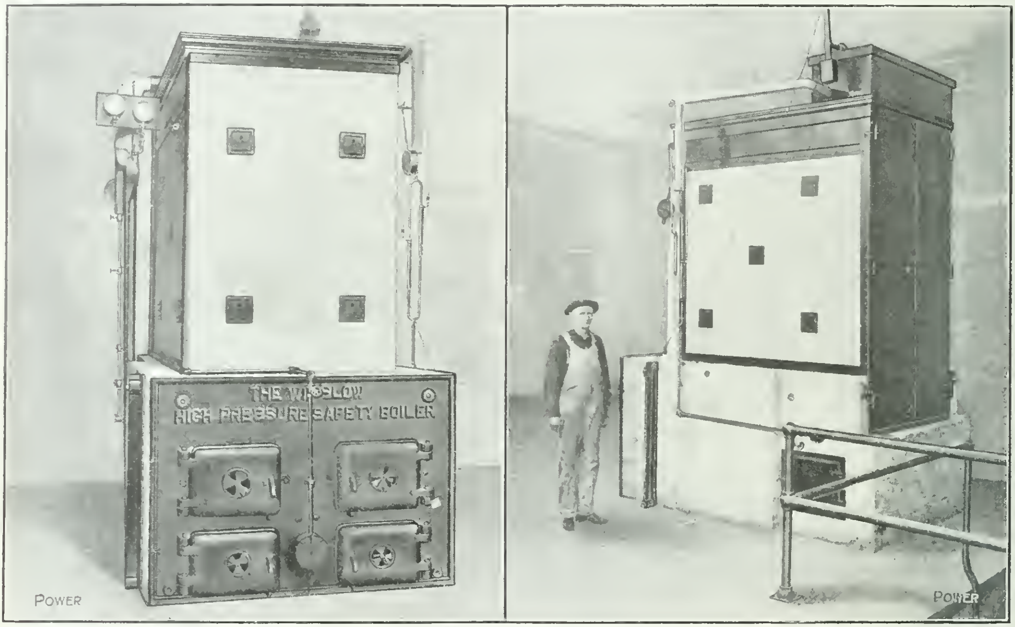


Fig. 6. Front and Side Views of Experimental Boiler

In this boiler, which was built for demonstration purposes, pressures up to 500 lb. have been carried and in the sections a superheat of 283 deg. has been obtained. Working under average conditions at 350 lb. and 200 deg. superheat, the boiler easily evaporates 8 lb. of water per pound of Pocahontas coal. The efficiency is, of course, largely a matter of furnace design.

With the sections filled, the boiler will hold 1080 lb. of water, and when three-quarters full, the normal condition, 810 lb. During the evaporation test referred to, 1900 lb. of steam per hour was drawn from the boiler. Dividing by 847, the total heating and superheating surface gives an evaporation of 2.24 lb. per sq.ft. of surface. Other tests were conducted to demonstrate the control over the boiler. Drawing steam at the above rate and with the fire burning briskly, the steam outlet was suddenly closed, the furnace door opened, and the result was an increase in pressure of from 10 to 15 lb. As a matter of fact, with so large a factor of safety, the safety valve would be set considerably above the working pressure and prevent undue waste of steam.

Arrangements have already been made to build engines and boilers for portable machinery and entrance into the power-plant field is anticipated. The engines are to be of the single-acting, unaflow type designed under the supervision of Prof. Stumpf. They will be operated at pressures of from 350 to 400 lb., and enough superheat to prevent initial condensation, probably about 100 deg. On engines of small power operating on a vacuum of 27 in. a rate of from 11 to 12 lb. per indicated horsepower-hour is expected, and noncondensing, a water consumption below 17 lb. In larger units operating with high superheat and vacuum, water rates close to 8 lb. per indicated horsepower-hour have been reported for the unaflow engine. The foregoing mentioned combination then has possibilities worth investigating.

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Coon Rapids Development

On Nov. 16, at a meeting of the Western Society of Engineers held in the interests of the Hydraulic, Sanitary and Municipal Section, J. W. Link, hydraulic engineer of H. M. Byllesby & Co., read a paper on "The Coon Rapids Low-Head Hydro-Electric Development on the Mississippi River."

This plant is equipped with five 2100-hp., single-runner waterwheels operating on an average head of 17.5 ft., and eventually it will have two more units of the same size. From Government stream-flow data for the years 1905 to 1913 inclusive, an annual average of 64,000,000 kw.-hr. may be expected from the seven units and 52,000,000 kw.-hr. from the five units installed. It is intended to use the water up to the full capacity of the equipment and, in connection with other water and steam plants under Byllesby control, to supply the demands of Minneapolis and St. Paul.

Mr. Link dwelt particularly on the interesting features of the construction work under the general heads of Hydrology, Borings, General Layout of Plant, Construction Camp, Foundations and Forms. Numerous lantern slides were shown, and of these the views showing methods of bracing and the large scroll case forms were of particular interest. A brief summary of the hydraulic and electrical equipment concluded the paper. As part of it supplements the article which appeared in "Power," June 30, 1914, it is given in the following:

The generating units are of the vertical type, each consisting of an Allis-Chalmers single-runner Francis turbine directly connected to a General Electric alternator and fitted with a roller thrust bearing and an oil pressure governor. The turbine runner, having a mean diameter of 8 ft. 6½ in. and a diameter over the discharge ring of 12 ft. 8 in., is set in a concrete scroll case with cast-iron pit rings. The wheel gates, which control openings 54 in. high by 13 in. wide, are of the swivel type with exterior operating ring and links. The rotating element of the machine is carried by a roller thrust bearing which rests on the upper spider of the generator. The length of the shaft from the center of the runner to the top of the roller bearing is 21 ft. 6 in. A water-lubricated lignum-vitæ guide bearing is carried by the upper cover plate of the turbine, and an oil-lubricated guide bearing is carried by the upper spider of the generator just below the roller thrust bearing. The shaft has a flanged coupling 3 ft. 7 in. above the lower guide bearing.

The roller bearing and the upper guide bearing are lubricated by a unit oiling system. The oil filter, storage tank and circulating pump are in the wheel pit. The motor-driven rotary circulating pump is mounted on the oil tank and forces the oil up to the bearings. The return of the oil to the filter is by gravity. The governor head and governor oil pump are driven by belts from a countershaft, which in turn is driven by bevel gears from the turbine main shaft.

The generator is a 1625-kv.-a., 2300-volt, 62-r.p.m. three-phase, 60-cycle machine, the rotor of which is 17 ft. 4 in. in diameter. The maximum load on the roller bearing, due to the weight of the rotating parts and to the downward thrust of the water, is 170,000 lb. Excitation of the alternators is furnished by two 300-kw., 720-r.p.m. motor-generator sets. A fifteen-panel switchboard provides the means for controlling the station.

For transmission to Minneapolis the current is stepped up to 13,200 volts by two banks of 1375-kv.-a., 60-cycle, single-phase, water-cooled transformers. The exciters, transformers and switchboard are located in compartments on the downstream side of the station and at the same elevation as the floor of the generator room. In a gallery over these compartments are the oil switches and lightning arresters. The transmission line consists of two circuits of 250,000 circ.mils solid copper wire, carried on cedar poles with wooden crossarms.

In detail, construction and general arrangement the entire equipment is so simple, strong and accessible that it is confidently expected that the operating and maintenance costs will be low. Arrangements are being made to determine the efficiency of the hydraulic turbines. High economy is anticipated.

Low-Pressure Turbines in Steel Mills[*]

By F. G. Cutler[†]

SYNOPSIS—Describes the savings made at the Ensley, Ala., steel works of the Tennessee Coal, Iron & Railroad Co., by using low-pressure turbines for furnishing air for blast purposes.

* * *

In hardly any other way has the reduction of operating costs in steel works been excelled, at least in relative values, than by the lowering of power costs and the saving effected by displacement of labor made possible by cheaper power.

This had been done by the installation of gas-engine-driven blowing engines and gas-engine-driven generators, motors on rolling mills to displace engines (which must necessarily have had sufficient capacity to handle the maximum load, and thus have been operating generally at an uneconomical load), together with the elimination of their attendant standby losses; also by the connecting of boiler houses by steam lines to utilize excess furnace gas and allow the shutting down of uneconomical boilers and the operation of others at a more economical load.

Other examples are the condensers on noncondensing units and improvements in economy of existing units by apparatus of higher economy, such as low- or mixed-pressure turbines.

REDUCTION OF POWER COST AT ENSLEY

A striking example of the possibilities of the last mentioned plan is afforded by the Ensley plant of the Tennessee Coal, Iron & R.R. Co. At the time of its acquisition by the corporation, this plant (consisting of six blast furnaces, 11 open-hearth furnaces, a blooming mill, a rail mill and shops) had seven boiler houses and two electric power stations, with a total rated capacity of 1800 kw. A third power station of 1800 kw. capacity had just been completed. All of the engines operated noncondensing, and no power was supplied to the outside plants. Additional electric power was required, and it was also necessary to materially increase the blowing capacity at the blast furnaces. All of this apparatus having been operated noncondensing, low-pressure turbines were of particular advantage, in that no change in engine conditions was needed.

By using low-pressure turbo-generators and low-pressure turbo-blowers with condensers and cooling towers at the blast-furnace blowing-engine house, two boiler plants have been dismantled, another at the local pumping station operates only occasionally, and two more at the steel plant are operated only during the time the mills are rolling, being shut down over Sunday, when the furnace boilers supply all the steam. All electric power is supplied for the operation of the American Steel & Wire byproduct plant at Fairfield and all that required to operate seven coal mines in the neighborhood of Ensley, resulting in the shutting down of several boiler plants and a reduction in load on others. Besides, the Birmingham, Ensley & Bessemer street railway is also supplied with power for the operation of 25 cars on 32 miles of single track.

This has been accompanied by an increase of product and a reduction in coal consumption. The saving in coal with the present equipment and methods of operating over former practice is estimated to be at the rate of 200,000 tons per annum.

LOW-PRESSURE TURBINES AT ENSLEY

Inasmuch as this is perhaps the largest equipment of low-pressure turbines in a steel plant in the country, it is appropriate to briefly describe the equipment and discuss the results obtained.

In the No. 2 power house, adjacent to the rail mill, are three 300-kw., 25-cycle, three-phase, 6600-volt generators operating at 1500 r.p.m., and driven by mixed-pressure turbines supplied with exhaust steam through five regenerators, each 8 in. diameter by 50 in. long, from two 55x66-in. twin reversing engines and a 52x72-in. corliss engine. Steam from the pressure pumps and air compressor (after the feed water heaters are supplied) is utilized for power.

The capacity of these regenerators is sufficient to absorb the extreme fluctuations in steam delivery. Under conditions requiring the use of all available low-pressure steam, there is no loss of exhaust steam at the back-pressure valves over long periods. This is accomplished without raising the back pressure on the engines over about four pounds.

At the No. 1 power house, near the blast furnaces, are three 3000-kw., 25-cycle, three-phase, 6600-volt generators and one corliss engine driving a 2000-kw., 6600-volt generator, the exhaust of these reciprocating engines being connected to a 3000-kw. mixed-pressure turbine similar to the three units in No. 2 power house, no regenerator being necessary on account of the relatively steady load. These two stations are operated in parallel and the load is divided between the two according to steam conditions.

TURBO-BLOWERS AT THE BLAST FURNACE

The turbo-blower equipment at the blast furnace consists of two mixed-pressure turbo-blowers, each of 55,000 cu.ft. per min. capacity, taking exhaust steam from 16 long crosshead-type vertical reciprocating blowing-engines, the air tubs of which have corliss inlet and poppet discharge valves, and one mixed-pressure, turbine-driven blower of 45,000 cu.ft per min capacity, taking steam from seven similar blowing engines. The last mentioned turbo-blower was originally a high-pressure, turbine-driven machine.

STEAM CONSUMPTION TESTS

To check the steam saved by the use of turbo-blowers, it is necessary to know the consumption of the original equipment. A test was made on five blowing engines; the principal data are given. The actual blast delivery was taken as 307.5 cu.ft. per revolution, as shown by previous calculations, the indicated horsepower, however, was based on indicator diagram results.

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[*] Excerpts from a paper entitled "The Use of Steam Turbines for Various Purposes," read at the October meeting of the American Iron and Steel Institute.

[†] Chief of bureau of steam engineering, Tennessee Coal, Iron & R.R. Co.

HEAT BALANCE TEST: STEAM CONSUMPTION OF BLOWING ENGINES

	R.p.m.	Blast Pressure Lb.	Volume of Blast at 307.5 Cu.Ft. per Revolution
Engine No. 20	35.2	15.81	10,825
Engine No. 22	41.7	15.81	12,830
Engine No. 23	43.4	11.11	13,350
Engine No. 24	35.4	11.11	10,890
Engine No. 25	32.3	11.11	9,940
Total	188.0		57,835
Total cu.ft. blast against		15.81	23,655
Total cu.ft. blast against		11.11	34,180
Indicated horsepower			3,473
Heat equivalent of work per hour, i.hp. × 2545			8,838,000
Radiation			49,500
Heat rejected above hotwell temperature, 2,000,000 lb. × (114.5 — 83)			63,000,000
Steam 142.7-lb. gage vacuum, 26.51 in. Quality, 98.5 per cent. Heat per pound above hotwell temperature B.t.u.			1,098.5
Pounds steam supplied to engines per hour			65,435
Dry steam supplied to engines per hour			64,450
Pounds steam per i.hp. of steam cylinders			18.5
Blast per min. at 15 lb. (23,655 × 1.01418) + (34,180 × 0.7855) cu.ft.			51,500
Steam per 100 cu.ft. at 15 lb. = 2.09 lb.			

The steam consumption of 2.09 lb. per 100 cu.ft. of blast at 15 lb. is about 3 lb. condensing, corresponding to a gross saving of 30 per cent. by these blowing engines being run condensing.

The latent heat in one pound of exhaust steam at 26.5 in. vacuum is 1024.4 B.t.u., and as approximately 957 B.t.u. per lb. of steam is given to the condensing water, the quality of the engine exhaust to the condenser in the above tests was about 93.4 per cent. The use of 3 lb. of steam per 100 cu.ft. of blast corresponds to 27 lb. steam per i.hp., this figure being checked by tests of the steam plants in the past, which give an efficiency as compared to the Rankine cycle of 54.5 per cent. By the use of the Mollier diagram, the quality of the exhaust steam from these noncondensing engines is found to be about 95 per cent.

On this basis, 3 lb. of dry steam delivered to the engines per 100 cu.ft. of blast would furnish 2.85 lb. dry exhaust steam, which in the turbo-blower would give

$$\frac{2.85}{307} \times 100 = 93 \text{ cu.ft.}$$

of blast; both engines and blower delivered against 15-lb. blast pressure.

SAVING FROM USE OF TURBO-BLOWERS

With blowing engines operating noncondensing, as was formerly the case at Ensley, a 30 per cent. saving in steam was made by condensing; by operating the same engines noncondensing and utilizing the exhaust steam in low-pressure turbo-blowers, a gross saving over original noncondensing conditions of about 93 per cent. was made, thus making the saving by the installation of turbo-blowers over condensing operation about 48 per cent. Local conditions requiring the use of cooling towers modify these figures somewhat, although the relative saving is not greatly different.

In summer, when the test was made, water from the cooling towers had a temperature of 95 deg., so that it was hardly possible to materially improve the vacuum of 26.64 in. With 28-in. vacuum, which it is possible to maintain with 75 deg. injection water available during the winter, the steam consumption of the low-pressure turbine would be improved at least 16 per cent., reducing the steam per 100 cu.ft. blast to 2.65 lb. This means that from the exhaust steam of the reciprocating, noncondensing blowing engines used in turbo-blowers exhausting into condensers at 28-in. vacuum, the actual blast delivery of these engines would be increased 113 per cent. For an average vacuum of 27.3 in., the actual blast delivery is practically double that of the noncondensing engines. In other words, from the steam used to blow three blast furnaces with high-pressure, noncondensing engines, three additional furnaces are blown by means of low-pressure turbo-blowers.

The term "blast unit," which is the blowing of 1,606,140 cu.ft. of blast against 15 lb. pressure, has been used as a unit of delivered power of blowing engines, and is the equivalent of the generation of 1000 kw.-hr. At Ensley, the cost per blast unit is $2.50 and is equivalent to a steam cost of one-quarter of a cent per kilowatt-hour.

USE OF TURBINES IN BYPRODUCT WORKS

The operation of turbo-blowers and exhausters in byproduct work is a comparatively recent service. The Tennessee company was the first to install them in this country, and probably the first anywhere to use them exclusively.

At the byproduct plant at Fairfield, there are five two-stage exhausters, each of 9,000,000 cu.ft. capacity in 24 hr., driven by three-stage, high-pressure turbines. Also at this plant there are two, three-stage, high-pressure turbo-boosters, one of 24,000,000 and one of 28,000,000 cu.ft. capacity, one operating at a time. With the usual type of apparatus, a much larger byproduct building and heavier foundations would have been required. The experience of nearly three years' operation has justified the claim that this type of apparatus has a lower operating cost for labor, repairs and lubricants, as well as steam; and with the exception of trouble with shaft packing, due to the action of gas on the metal used originally, the installation has been successful in every way.

There is a peculiar advantage in the use of turbo-exhausters in byproduct service, in that the centrifugal action of the blower throws out the small particles of tar or tar fog carried with the gas, greatly reducing the work required of the tar extractors, which are located between the exhausters and the saturators. Three per cent. of the total tar production of the plant is recovered from the drains on the turbo-exhausters.

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English Mechanical Engineers' Refrigeration Report

The refrigeration research committee of the Institution of Mechanical Engineers, England, made its report at the October meeting, an abstract of which follows:

The most important part of the report is that which relates to the standard that should be used for the practical rating of refrigerating machines as a means of expressing the amount of refrigerating effect which the machine is capable of producing under specified conditions. For the purpose of practical rating, engineers are concerned not directly with the limit of temperature of the working substance, but with the temperatures external to the machine between which the heat is pumped. In the normal case of a machine working under steady conditions to keep brine cold by extracting heat from it and discharging the heat to cooler water, the temperatures to be considered for the purpose of rating are four, the upper and lower temperatures of the brine and the upper and lower temperatures of the cooling water.

For rating purposes, definite values have to be assigned to these four temperatures. The following are considered to be suitable for adoption as standard values:

For brine, upper limit, 0 deg. C., 32 deg. F. Lower limit, minus 5 deg. C., 23 deg. F.

For cooling water, upper limit, 20 deg. C., 68 deg. F. Lower limit, 15 deg. C., 59 deg. F.

In specifying the standard conditions, the range through which the brine is cooled (5 deg. C.) has been made somewhat wider than usual, with the object of facilitating the accurate measurement of refrigerating effect in tests made for the purpose of rating. Relative to the method of specifying the amount of heat extracted per unit of time, the committee has considered the practice occasionally resorted to of using a unit based on the making of ice from water at 0 deg. C. or at some arbitrarily chosen temperature. It is of the opinion that the objections to such a method of rating are so serious that it cannot recommend it. Any rating on an ice-making basis is likely to be confused with the actual output of a machine employed in the manufacture of ice, which may be very different. The committee arrived at the conclusion that the most simple and unambiguous form of statement would be to express the cooling effect of a machine in calories per second, the calorie being the amount of heat required to change the temperature of 1 kg. of water by 1 deg. C. One calorie is

$$2.2046 \times {}^{9}/_{5} = 3.9683 \text{ B.t.u.}$$

One calorie per second is therefore equivalent to

$$3.9683 \times 60 \times 60 \times 24$$

or about 342,862 B.t.u. per day; 288,000 B.t.u. per day as a unit of refrigerating effect is recognized in the United States, and it has been suggested that 322,000 B.t.u. be used as a British standard. It will be seen therefore that the calorie per second is a unit of much the same order of magnitude, only slightly larger.

The committee accordingly recommended: First, that the refrigeration produced by a refrigerating machine be expressed in calories per second. This unit is equivalent to 342,862 B.t.u. per day of 24 hours. Second, that the refrigeration may be stated for particular conditions or for standard conditions. Third, that the standard conditions be defined as follows: The temperature limits to be steady; the temperature of the cooling water to range from 15 deg. C. (59 deg. F.) at inlet to 20 deg. C. (68 deg. F.) at outlet, and the temperature of the brine to range from 0 deg. C. (32 deg.

F.) to —5 deg. C. (23 deg. F.). Fourth, that the refrigeration produced under standard conditions be called the rated capacity of the machine.

In cases of cooling by direct expansion without the use of brine, the same method of rating will apply except that the condition has to be modified by specifying for the lower limit of temperature that of the working substance itself. It is considered that a temperature of —10 deg. C. (14 deg. F.) as a lower limit for the working substance will harmonize with the conditions which have to be laid down for machines using brine, and this figure will also be in accordance with the standards of the temperatures adopted by the Association Francaise du Froid. The committee accordingly recommends that in the rating of a direct-expansion refrigerating machine, the temperature of the vapor in the evaporator be taken at —10 deg. C., and that the conditions as regards cooling water be the same as those laid down for machines using brine.

The accompanying table gives the calorie equivalent of the B.t.u. for time periods varying from 1 sec. to 1 day. It will be found useful in calculating the capacities of refrigerating machines on the basis recommended by the committee.

The theoretical performance in a vapor compression machine using any assigned working substance assumes adiabatic compression to take place between constant pressure limits of suction and discharge. These two pressures must be known, also the temperature to which the working fluid may be cooled before passing the expansion valve. With these three data there will be for any working substance some particular degree of dryness—i.e., some particular proportion of vapor to liquid at the beginning of compression which with adiabatic action will theoretically be best in the sense of giving the maximum coefficient of performance in the ideal cycle. When the degree of dryness at the beginning of compression is determined, the temperature of superheating reached at the end of compression follows. The essential data therefore for determining the ideal cycle are the suction and discharge pressures, and the temperature before the expansion valve, if the cycle is specified as that which, with those temperatures assigned, will give the highest coefficient of performance in adiabatic action. Further, in order to secure the highest ideal efficiency, the working substance should be cooled before passing the expansion valve to a temperature as nearly as possible equal to that of the supply of cooling water. It is therefore proposed in all cases to take the temperature at which cooling water is supplied as the temperature to which the working substance is supposed to be cooled before passing the expansion valve in calculating the ideal cycle of comparison.

It is accordingly recommended that the ideal cycle to be adopted as a standard for comparison with actual performances be the most efficient cycle employing adiabatic compression in which the pressure of suction and condensation are the same as those that occur in the actual process of working, and in which the substance is cooled before passing the expansion valve to a temperature equal to that at which in the actual process the cooling water is supplied. The pressures should be measured just after and just before the substance passes through the expansion valve.

This last recommendation is required to make the conditions for compression definite in cases where there is any substantial drop in pressure between the compressor delivery and the expansion valve, or between the lower side of the expansion valve and the compressor intake. In some refrigerating machines, the action is compound in that compression occurs in two stages, with cooling of the substance between the two, or the expansion by throttling takes place in two stages with a return of part of the substance to the compressor after the first stage.

The committee does not consider it necessary or advisable to complicate the use of a standard cycle of comparison by specifying ideal cycles special to such operation. It thinks it better that any actual machine employing such a compound process for getting an augmented efficiency should still have its performance compared with that of the ideal machine using the standard cycle. The coefficient of ideal performance C is found by dividing the heat taken in by the work expended in the standard cycle. Similarly, the coefficient of actual performance Ca is found by dividing the refrigerating effect actually produced by the work expended in driving the compressor in the real performance of the machine. The ratio $\frac{Ca}{C_1}$ is a fraction which shows how nearly the real performance approaches the standard idea, therefore this ratio may be called a relative efficiency.

The coefficient of actual performance is found by direct measurement of the refrigerating effect produced in actual working and of the work expended. The work may be reckoned either as the indicated work done in the compressor or as the total work required to drive it. As the indicated work is materially less, it is important in all statements of actual performance that one states clearly which of the two methods of reckoning is employed.

B.T.U. CALORIE EQUIVALENTS FOR DIFFERENT UNITS OF TIME

	B.t.u. per Sec.	B.t.u. per Min.	B.t.u. per Hr.	B.t.u. per Day	Cal. per Sec.	Cal. per Min.	Cal. per Hr.	Cal. per Day
B.t.u. per sec.	1	60	3600	86,400	0.2519958	15.1197480	907.18488	21,772.43712
B.t.u. per min.	0.01667	1	60	1,440	0.0419993	0.2519958	15.119748	362.873952
B.t.u. per hr.	0.000278	0.1667	1	24	0.00069999	0.0419993	0.2519958	6.0478992
B.t.u. per day	0.00001151	0.0000695	0.04167	1	0.0002916	0.0017499	0.1049922	0.2519958
Cal. per sec.	3.96832	238.0992	14,285.952	342,862.848	1	60	3600	86,400
Cal. per min.	0.066105	3.96832	238.0992	571.438	0.01667	1	60	1,440
Cal. per hr.	0.0011023	0.066138	3.96832	95.2397	0.000278	0.1667	1	24
Cal. per day	0.0000459	0.0660960	0.165240	3.96832	0.00001151	0.0000695	0.04167	1

1 calorie = 3.96832 1 B.t.u. = 0.2519958

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Pan-American Scientific Congress

The United States, through its Department of State, has invited all the governments of this hemisphere to a Pan-American Scientific Congress to be held in the City of Washington in October, 1915. This is the second congress, the first one having been held in Santiago, Chile, Dec. 5, 1908.

Judging from the previous congress, this one will presumably have departments of Pure and Applied Mathematics, Physical and Chemical Sciences; another group of Anthropology, Ethnology, Zoölogy and Botany, Geology and related subjects; on Engineering; on Medical Science and Hygiene; on the Juridical Sciences, and then possibly something on History, International Law, Pedagogy, Agronomy and Zoötechnics, etc.

The Department of State has invited the five national engineering societies, civil, mining, electrical, naval architects and mechanical engineers to assist in the preparation of the program on Engineering. This assistance should be more comprehensive than simply preparing a technical program; it should include the suggestions of the authors, the suggestion of the names of the biggest men in the engineering field in the different countries, and then urge directly or indirectly, through our various affiliations, technically, commercially and diplomatically, the appointment by the various governments of these men of affairs as delegates to the congress; then, after getting them here, it should be seen that adequate reception is provided by the industrial concerns of America, whether leading to the cultural relations between the countries of North, South and Central America, the development of mutual confidence, or, from the American point of view, the development of the confidence of the other countries in our manufactured products, so that when these delegates return, the commerce in our products could be reasonably expected. This feature is mentioned with bluntness and frankness because there is nothing undignified in the parallel program outlined of

(a) A scientic congress, and

(b) The incidental visits to the industries.

On the contrary, we would gain not only in the attendance on the one, but in the benefits of the other by openly enhancing the attractiveness of the program of the technical congress by the practical features of the industrial business. Further, by showing exactly what we have in mind, we ought to get the active interest of the men of affairs in this nation in a matter that has been dragging along for four or five years.

※

Precautions When Heat Is Applied To Ammonia Drums—Engineers who have the habit of pouring hot water over the ammonia shipping drums to facilitate charging the ammonia into the system and those who have a steam jet to impinge against the drum, or wrap cloth around the drum and stick the end of the steam hose under the cloth should avoid closing the valve on the pipe connection between the shipping drum and the charging pipe while the drum is hot or the drum will probably explode.

BOOKS RECEIVED

STEAM POWER PLANTS—By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 299 pages, 6x9 in.; 183 illustrations; tables. Price, $2.50.

HEATING AND VENTILATING PLANTS—By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 308 pages, 6x9 in.; 207 illustrations; tables. Price, $2.50.

NEW PUBLICATIONS

OIL FUEL FOR STEAM BOILERS. By Rufus T. Strohm. Published by McGraw-Hill Book Co., New York, 1914. Size 4½x7 inches; 139 pages; illustrated. Price $1.

This little book forms one of the "Power Handbook Series" and is a practical discussion of the essentials of oil-fuel practice as applied to stationary steam boilers. The subject is handled under the following divisions: Properties of Oil Fuel, Requirements for Efficient Burning, Methods of Spraying, Burners, Cleaning of Oil Fuel, Pumping and Heating, Oil-Burning Furnaces, Installation of Burners, Storage of Oil; Management of Oil-Burning Plants, Purchase of Oil, and Advantages and Disadvantages of Oil Fuel. While the results of a few tests are given, the number might have been increased and thus given the book more value as a work of reference.

ELECTRIC MOTORS. By Francis B. Crocker and Morton Arendt. Second Edition. Published by D. Van Nostrand Co., New York, 1914; Size 6x9 in.; 300 pages; illustrated. Price, $2.50.

As a reference book on the characteristics and applications of electric motors of various types, it has few equals. No attempt has been made to go into questions of design, the treatment being essentially from the operating standpoint. Nevertheless, it is not in any sense an elementary treatise, and, although theory has been subordinated to practical considerations, the book will find its greatest field among students, electrical engineers and operating engineers who already possess a grounding in electricity.

MARINE BOILER MANAGEMENT AND CONSTRUCTION. By C. E. Stromeyer, M. Inst. C. E., Fourth Edition. Longmans, Green & Co., London, New York, Bombay and Calcutta; 1914; 6x9; 410 pages; illustrated; cloth; $4 net.

One could hardly have a better training for an appointed test than has Mr. Stromeyer for the production of a book upon boilers. To an adequate technical training, signalized by a membership in the council of the National Physical Laboratory at Kew, he adds years of service as engineer surveyor to Lloyd's Register, which probably accounts for the "Marine" in the title, and more recently has been chief engineer of the Manchester Steam Users' Association for the Prevention of Boiler Explosions.

The work was issued originally in 1893, the present being its fourth edition. Notwithstanding the title, it is not exclusively nor even principally of value to marine engineers. After the first chapter, Boiler Management, is finished, the builder and user of stationary boilers will find as much of value in his field as will the marine engineer in his own line. The present edition has been revised to take account of recent experimental researches, among which may be mentioned those of Stefan and Bolzmann upon radiation, which seem to explain why the high-temperature flames which are associated with perfect combustion lead to furnace troubles; Nicholson's experiments on the influence of the speed of gas on its heat transmission; Coker's optical measurements of strain, and the author's own experiments on the fatigue of metals, on brittleness caused by the presence of nitrogen in steel, on water-hammer in steam pipes, and the exhaustive experiments of Heyn and Bauer on corrosion. The rules of Lloyd's Register and the Board of Trade, together with tables based thereon, are given in extenso in the concluding chapters.

LESSONS IN MECHANICS FOR MARINE ENGINEERS AND ENGINEERING STUDENTS—By A. N. Somerscales, late lecturer in Steam, Mechanics and Mechanical Engineering at the Hull Young People's Institute. Published by James Munro & Co., Ltd., Glasgow, Scotland; D. Van Nostrand Co., 25 Park Place, New York. Size, 4½x7½ in.; pages, 272; cloth binding; illustrated. Price, $1.50.

Like many another textbook, this one grew out of a series of lessons prepared for a certain class of students for whom there seems to be no appropriate work already published. The lessons were originally for the evening classes of students at the Hull Young People's Institute and were an attempt to teach the groundwork of applied mechanics without using any mathematics beyond arithmetic. It was with a similar purpose in view that "Power's" Engineering Study Course in Elementary Mechanics was written. It is interesting to compare the two for this reason, but this is not the purpose of the present review. The book would, however, appeal to those who followed our course and might prove a beneficial means of further grounding the study of the elements of the subject.

In this book, to take the place of algebraic and trigonometrical demonstrations of the principles, simple experiments are described. The examples and exercises were selected especially for marine engineers, but the treatment is such as to interest engineers of all kinds.

COMPRESSED AIR PRACTICE—By Frank Richards. Published by McGraw-Hill Book Co., New York. Size, 6x9 in.; 326 pages; 96 illustrations. Cloth. Price, $3.

Only a small proportion of the material of the author's book "Compressed Air," which made its appearance about fifteen years ago, is to be recognized in the present volume and with an improvement in the method of treatment. Definitions and general information on the properties of air and an explanation of the compressed air problem are given in a manner that will be appreciated by those who know little about the subject or who may have despaired of gaining knowledge from authors who have too frequently appeared to regard the subject as an arena for the display of mathematics.

The author's treatment is confined to simple arithmetical and algebraical methods of computation, the work being intended "for those who know little about air rather than for those who mostly know all that is known," and "those who need more accurate and detailed information for practical guidance may perhaps derive some hints of how it may be obtained."

Tables and diagrams are given for computations of compressed air and separate chapters are devoted to the use of the indicator, single-stage, two-stage and three-stage compression, and on the various methods of compressing air; also on power cost, power from compressed air, the air lift and other methods of employing compressed air for raising water and on the leading practical applications, the last chapter being devoted to liquid air and the separation of oxygen from the atmosphere.

The illustrations are good, and although the work treats of latest improvements in machinery for compressing air, it is exceptionally free from catalog literature.

TECHNICAL MECHANICS. By Edward R. Maurer, professor of mechanics in the University of Wisconsin. 6x9 in., 363 pages. Price, $2.50. Published by Wiley & Sons.

This book is intended to illustrate only those principles of mechanics applicable to engineering problems, without giving an excess of detail relative to the construction of the machine or mechanism itself. The work is divided into two parts—Statics, consisting of six chapters, and Dynamics, which comprises the latter part of the book. This arrangement is to be commended, as the subject of statics is simpler and further because the mind of the average student grasps the idea of rest more readily than that of motion.

An exceptionally good feature is the collection of problems placed at the end of the text; in fact, throughout the work the principles are clearly illustrated by practical examples, demonstrating the fact that fundamental principles can only be grasped by the analysis and solution of many problems. The subject of statics is so presented that the more important parts may be mastered by anyone with a fair knowledge of trigonometry.

In the first chapter the author goes into considerable detail to explain the composition and resolution of forces. The next chapter gives the general conditions of equilibrium for all possible combinations of forces, and in the following chapter these principles are applied to the various forms of roof trusses and cranes so as to give an excellent opportunity for introducing graphical statics.

Unless the student is well up in his mathematics, he may find that part of the work dealing with dynamics considerably more difficult. The chapter on work, power and energy contains practical information relative to train resistance, drawbar pull, cylinder effort and other items relating to the motion of trains.

The book is the result of the author's experience for a number of years in the use of the former edition, and should, therefore, eliminate many of the objections usually found with works on mechanics, and it should prove of great help, both as a text and as a reference book.

⁂

Bad Effects of Leaks in Steam Mains—Leaks in steam mains may short circuit the electrical connections. They also cause doors to swell and damage the adjoining woodwork.

POWER

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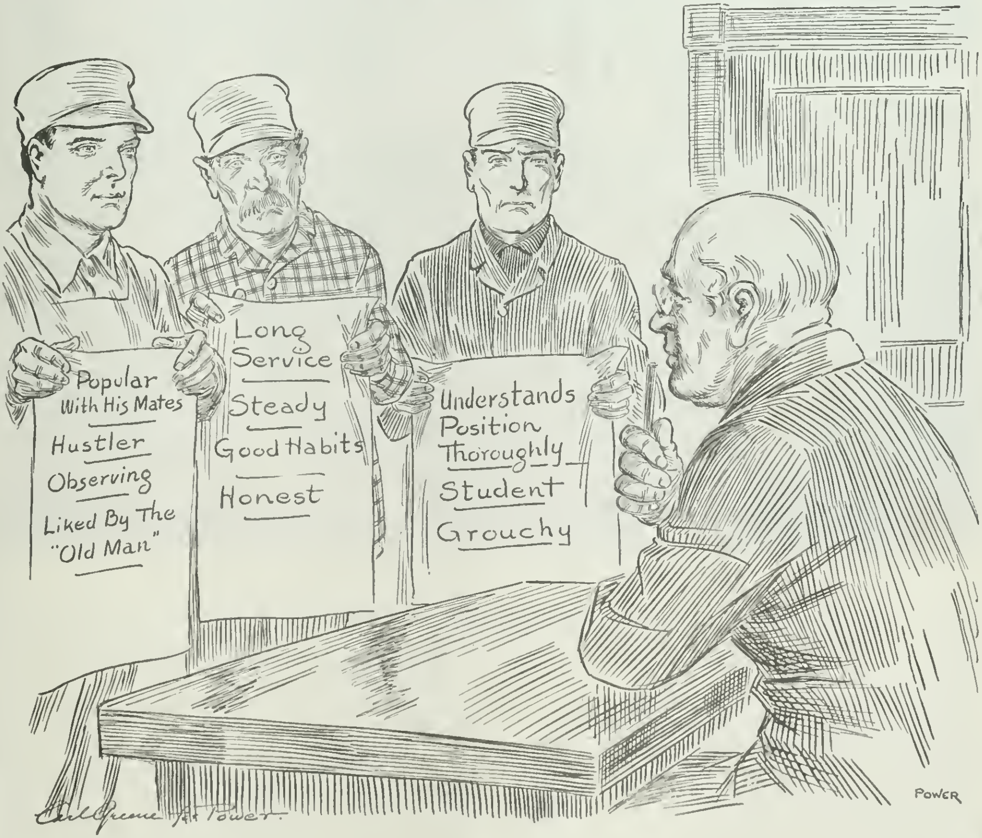
A Problem



WHO GETS THE PROMOTION?

Detroit's Municipal Lighting Plant

By Thomas Wilson

SYNOPSIS—Beginning in a small way in 1895, the plant now has a capacity of 11,450 kw. to supply all lighting for streets, parks and public buildings. Last year the output was 15,677,255 kw.-hr. and the operating cost 0.641c.

⁂

A decidedly successful municipal station is the public lighting plant of Detroit. In operation nearly 20 years, each annual report has shown a reduction in the cost per unit output and in the annual charge per lamp for current and attendance. The plant and line equipment have been kept in good repair and additions to the generating capacity have been made as the increasing load required. Later types of prime mover and generator replaced the older units until now the load is carried by horizontal reaction turbo-generators at an operating cost of 0.64c. per kw.-hr.

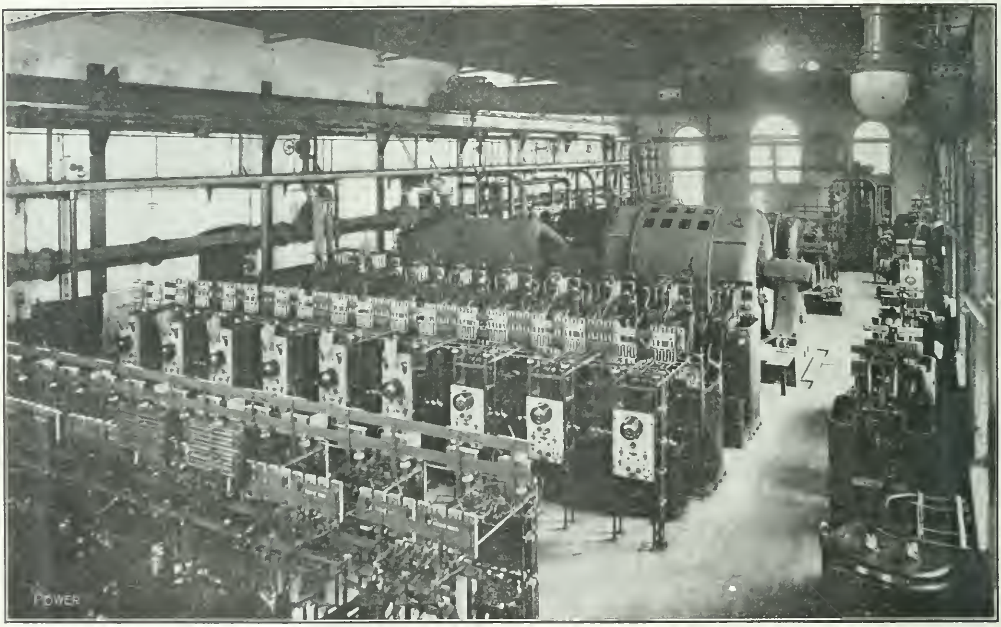


Fig. 1. Generating Room of the Public Lighting Plant

It may not be generally known that Detroit was one of the first cities to adopt the electric arc lamp for street lighting. The first contract was made in 1883 for 22 arc lamps, at 50c. per lamp per night, operated on a moonlight schedule. The next year, in 1884, a contract was made for 300 arc lamps on an all-night schedule. The contract price was $95,000 for the year, or $316.67 per lamp. Following contracts somewhat reduced the rate, but the lowest was $132.41 for each lamp for the year. This was found to be higher than was paid in many other cities. For this reason, and because the service was unsatisfactory, the citizens of Detroit decided to build a municipal plant. The first lamps operated from a public lighting plant were put in service in April, 1895, and the lighting of the city by the municipal plant began Oct. 1 of the same year.

The cost per lamp for operation and maintenance—not including fixed charges such as interest, depreciation, etc., for the year ending June 30, 1896, was $68.52. The same cost for the year ending June 30, 1914, was $25.21. The greater part of this reduction has been made possible by the substitution of modern and more efficient apparatus for the equipment originally installed. As shown in Table 1, it has been gradually effected from year to year, showing that efforts in this direction were unremitting.

The plant was built for a capacity of 2000 arc lamps. Five marine-type engines belted to twenty 50-kw. arc dynamos and three 57½-kw. direct-connected arc dynamos furnished the electrical energy. This equipment practically filled all the available floor space in the engine room. Today, with an extension of only 16 ft. to the engine room, the generating capacity consists of two 600-kw., two 2000-kw. and one 6250-kw. units. The two 600-kw. generators are connected to reciprocating engines, one of the Willans three-line, triple-expansion type and the other a

TABLE 1—ANNUAL COST PER ARC LAMP

Fiscal year ending June 30,		Fiscal year ending June 30,	
1896	$68.52	1906	$33.18
1897	64.19	1907	33.25
1898	51.85	1908	34.65
1899	46.46	1909	32.17
1900	40.30	1910	30.34
1901	42.59	1911	29.93
1902	39.45	1912	27.10
1903	41.03	1913	25.49
1904	40.16	1914	25.21
1905	34.99		

triple-expansion, marine-type engine. The two 2000-kw. generators are driven by horizontal reaction turbines served by barometric condensers, each having a capacity to condense 50,000 lb. of steam per hour. These machines have been carrying the bulk of the load, which has now reached the limit of their capacity. For protection against shutdown another unit was badly needed, and a substantial increase in the number of arcs for the coming year made additional generating capacity imperative. A new turbine unit, of the semi-double-flow type and rated at 6250 kw. at 70 per cent. power factor, has just been installed. It will be served by a surface condenser having 8000 sq.ft. of cooling surface, or 1.28 sq.ft. per kilowatt of generator rating. With steam at 160 lb. gage and 100 deg. of superheat and cooling water at 40 deg., the guaranteed steam consumption per kilowatt-hour is 13.15 lb.; with 70 deg. water the rate increases to 13.9 lb.

In the boiler room the old 300-hp. boilers with hand-fired furnaces are being gradually replaced by larger boilers with modern stokers. There are now five 400-hp. water-tube boilers and five 300-hp. boilers. Three of the smaller capacity have just been removed and within the year they will be replaced by three larger boilers. The present capacity then is 3500 boiler horsepower. The new units will add 1200 hp., giving a ratio of 1 boiler horsepower to 2.43 kw. of generating capacity. A coal conveyor raising the fuel to overhead bunkers has been in operation for about two years.

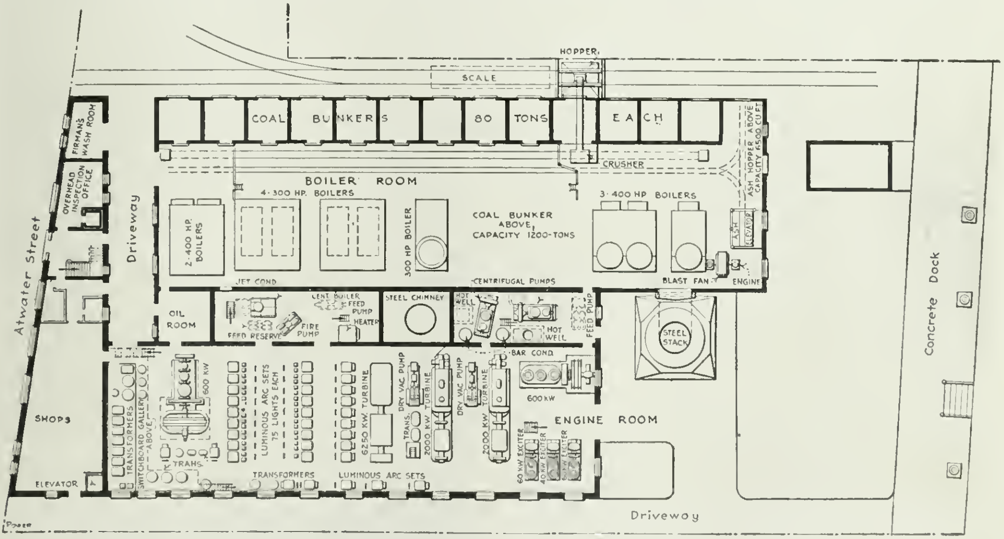


Fig. 2. General Plan of the Station

These improvements in the boiler and engine rooms can be checked from one year to another by the reduction in consumption of coal per unit output. In 1908 the coal burned per kilowatt-hour averaged 5.23 lb.; last year's records show 3.42 lb. per unit, a reduction of more than 34 per cent. Table 2 gives the average monthly figures for the last six months. During this time the grade of coal used has been approximately the same. All coal is purchased on a penalty basis. This year's contract for West Virginia nut, pea and slack, on a contract guarantee of 14,143 B.t.u. per lb., is on the basis of $2.25 per ton, delivered on the siding of the plant.

About as good a showing has been made in reduction of costs in other directions. The trimming of the Brush arc lamps, which in 1898 cost $16.54 per lamp, per year, for carbons, globes and labor, was reduced to $3.98 per lamp when series alternating-current arcs replaced the Brush lamps; it was again reduced to an average of about $2.06 per lamp per year for the 4-amp. luminous arcs, which are gradually replacing the series alternating-current lamps. Of the latter there are only 2337 in operation, and these are in the outlying districts of the city.

TABLE 2—COMPARATIVE AMOUNT OF COAL CONSUMED

Year ending June, 30,	1914		1913	1912	1911	1910	1909
	Lb. Coal Consumed	Lb. per Kw.-Hr.	Lb. per Kw.-Hr.	Lb. per Kw.-Hr.	Lb. per Kw.-Hr.	Lb. per Kw.-Hr.	Lb. per Kw.-Hr.
July	3,257,054	3.50	3.59	3.88	4.40	5.19	4.64
August	3,377,501	3.29	3.30	3.60	4.10	4.98	4.61
September ..	3,637,994	3.12	3.45	3.43	3.90	4.72	4.63
October	4,817,727	3.36	3.33	3.27	3.92	4.39	5.30
November ...	5,511,982	3.60	3.88	3.26	3.49	4.23	4.32
December ...	6,070,874	3.65	3.63	3.24	3.49	4.22	4.53
January	5,492,912	3.26	3.43	3.49	3.25	4.31	4.70
February ...	4,894,079	3.47	3.61	3.64	3.50	4.47	4.90
March	5,067,349	3.55	3.27	3.42	3.38	4.63	5.07
April	4,438,862	3.58	3.52	3.20	3.51	4.91	5.19
May	3,889,917	3.38	3.53	3.42	3.76	4.93	5.10
June	3,325,194	3.29	3.55	3.29	4.07	4.74	5.22
Totals ...	53,781,445	3.42	3.51	3.43	3.68	4.59	4.84

At present 7376 arc lamps are in service and about 1500 more will be added during the year. The time of lighting for the year ending June 30, 1914, totaled 3917 hr. 10 min., and the average per night was 10 hr. 42 min. The average number of arcs operated during the year was 6684. The lamp-hours scheduled were 27,401,524 and the lamp-hours out, due largely to line, lamp and station troubles, were 50,491, a ratio of only 0.18 of 1 per cent.

In addition to the arc lighting, service is supplied to more than 200 public buildings, including school houses, fire-department engine houses, police stations, libraries, public parks, etc. This also includes service for a con-ted load of 1427 hp. in motors and more than 30,000 incandescent lamps.

Last year the output was 15,677,255 kw.-hr., divided between arcs and incandescents, as shown in Table 3; under the latter heading motors are included. The cost of operating the plant is given in detail in Table 4 for the year ending June 30, 1914, and the totals for four years. The total operating expense is divided under the various heads of maintenance, executive, station, lighting and some miscellaneous items. The division referring to the station operating expense is naturally of the greatest interest, as these data are directly comparable with statistics from any type of generating plant. The fuel cost per unit of output forms a good basis on which to judge the economy of the plant. In the present instance a charge of 0.393c. per kw.-hr. may be considered excellent. The wages add 0.232c., supplies 0.013c. and oils 0.003c. A total operating expense of 0.641c. per kw.-hr. compares favorably with the best of privately owned plants, and this good showing was made during a period of reconstruction. With the large unit carrying the load and being supplied with steam from the boilers equipped with stokers, a reduction in the operating expense may be expected.

TABLE 3—COMPARATIVE KILOWATT-HOUR OUTPUT
(Twelve months to June 30, 1914)

	Arc	Incandescent	Total
July	759,041	171,434	930,475
August	856,499	170,481	1,026,980
September	962,138	205,797	1,167,935
October	1,127,833	304,932	1,432,765
November	1,219,437	313,113	1,532,550
December	1,327,618	335,272	1,662,890
January	1,325,199	360,501	1,685,700
February	1,113,313	296,587	1,409,900
March	1,117,665	309,375	1,427,040
April	986,070	255,360	1,241,430
May	920,976	228,934	1,149,910
June	827,210	182,470	1,009,680
Totals	12,542,999	3,134,256	15,677,255

Adding the other items to the operating expense gives a total of 1.45c. per kw.-hr. A comparison with other years shows that there has been a gradual reduction, except that the unit cost for 1913 is just a shade lower than for the present year.

From the inauguration of the plant up to June 30, 1914, $2,847,567.80 has been expended for the building and site and the plant equipment, substations and line: The amounts charged off for depreciation, etc., lower this to $2,102,984.30. In round numbers the value of the station proper is $767,000, or $67 per kw. of rated generating capacity. This includes the building and the site but no part of the equipment of the line or the substations.

To make the generating cost comparable with other plants, it would then be necessary to add to the operating expense of 0.641c., given in Table 4, a 12 per cent. charge on the investment to cover interest, depreciation, insurance and taxes. The city, of course, does not pay taxes on its own property and other plants do. On $767,000, a yearly charge of 12 per cent. amounts to $92,040, and dividing by the output, the total reduces to 0.58c. per kw.-hr. Adding the operating and fixed charges, the total cost per kilowatt-hour is 1.22c.

The plant is favorably located on the river bank, about half-way between the east and west limits of the city. Coal and carload lots of supplies are delivered directly into the station yard over a spur track.

All electrical energy is generated at 2300 volts, two-phase. For outlying districts this voltage is raised to 5500 and 6600 volts and distributed to five substations (about 3½ miles from the main station), from which the several arc circuits for the respective districts are carried.

The wages of the help are about the same as those paid by Detroit private corporations for the same service.

TABLE 4—COST OF OPERATING PLANT, FISCAL YEAR ENDING JUNE 30, 1914

Output this year ending June 30, 1914.... 15,677,255 kw.-hr.
Output last year ending June 30, 1913.... 13,787,975 kw.-hr.

	Wages	Stores	Total	Cost per Kw.-Hr.
Maintenance—				
Buildings, track, dock, etc.	$1,830.05	$3,079.90	$4,909.95	......
Steam plant	4,306.23	3,490.99	7,797.22	......
Electric plant	1,753.49	947.39	2,700.88	......
Miscellaneous tools and machinery	894.82	1,770.61	2,665.43	......
Conduits	909.20	527.42	1,436.62	......
Towers and lamp posts	2,934.30	524.23	3,458.53	......
Arc lamps and switches	5,563.75	2,667.88	8,231.63	......
Lines and cables	19,093.88	10,216.19	29,310.07	......
Total maintenance	$37,285.72	$23,224.61	$60,510.33	$0.00385
Executive—				
Salary secretary and city electrician	$8,000.00	....	$8.000.00	......
Printing and stationery	....	$1,006.15	1,006.15	......
Storeroom	3,205.57	71.10	3,276.67	......
Office expense	6,123.86	381.12	6,504.98	......
Superintendent and drafting	5,671.65	83.40	5,755.05	......
Total executive	$23,001.08	$1,541.77	$24,542.85	$0.00157
Station—				
Oils	....	$424.12	$424.42	$0.00003
Waste	....	34.07	34.07	0.00000
Coal	....	61,614.72	61,614.72	0.00393
Miscellaneous supplies	....	1,982.28	1,982.28	0.00013
Wages	$36,448.50	....	36,448.50	0.00232
Total station	$36,448.50	$64,055.49	$100,503.99	$0.00641
Lighting—				
Trimming and patrolling	$18.228.45	$313 82	$18,542.27	......
Electrodes	....	7,705.12	7,705.12	......
Rectifier tubes	....	1,848.10	1,848.10	......
Incandescent lamp renewals	....	3,945.73	3,945.73	......
Incandescant lighting expense	958.24	576.33	1,534.57	......
Globes	....	2,530.74	2,530.74	......
Miscellaneous supplies	....	95.23	95.23	......
Belle Isle Park	599.44	93.53	692.97	......
Palmer Park	152.43	31.52	183.95	......
Total lighting	$19,938.56	$17,140.12	$37,078.68	$0.00237
Shop supplies	....	$24.90	$24.90	$0.00000
Surgeon and hospital	$330.93	582.05	912.98	0.00006
Relief fund	3,757.52	....	3,757.52	0.00024
Total operating cost	$120,762.31	$106,568.94	$227,331.25	$0.01450
12 months to June 30, 1913	$108,036.66	$90,479.77	$198,516.43	$0.01440
12 months to June 30, 1912	102,080.00	85,732.96	187,813.05	0.01538
12 months to June 30, 1911	99,396.37	80,171.52	179,567.89	0.01686
12 months to June 30, 1910	91,022.46	80,238.65	171,261.11	0.01710

The working day is eight hours. Every year ten days' vacation with pay is given to each employee. In case of injury while on duty, all expenses for medical attendance are paid by the commission, and full pay is given to the injured employee during the time that he is incapacitated. That conditions are agreeable to the workmen is proved by the fact that in every department there are employees who helped in the construction and first year's operation of the plant.

That the municipal plant of Detroit is a success is due to the ability of Frank R. Mistersky, general superintendent, and to the caliber of the men who have served as public lighting commissioners. Some of Detroit's most eminent citizens have considered it an honor to be able to serve the city and have given liberally of their valuable

PRINCIPAL EQUIPMENT OF DETROIT PUBLIC LIGHTING PLANT

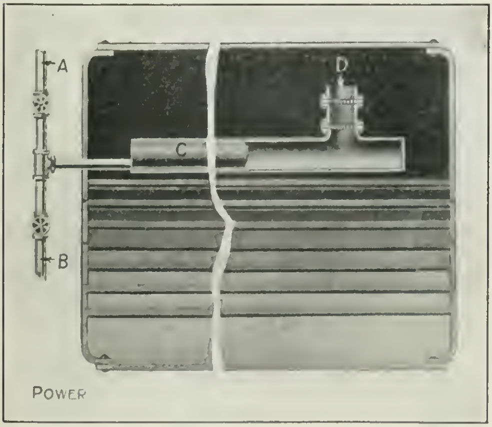
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Double deck tubular	300 hp.	Generate steam	160 lb. pressure, hand fired	Sharkey & Peck
4	Furnaces	Down-draft	46 sq.ft.	Serving Peck boilers		Hawley Down Draft Furnace Co
1	Boiler	Vertical water-tube	300 hp.	Generate steam	160 lb. pressure	Wickes Boiler Co.
1	Stoker	Detroit	56 sq.ft.	Serving Wickes boiler		Detroit Stoker Co.
3	Boilers	Vertical water-tube	400 hp.	Generate steam	160 lb. pressure, 100 deg. superheat	Wickes Boiler Co.
3	Stokers	Underfeed	Projected area 43 5 sq.ft.	Serving Wickes boilers		American Engineering Co.
2	Boilers	Stirling	400 hp.	Generate steam	160 lb. pressure	Babcock & Wilcox Co.
2	Stokers	Underfeed	Projected area 43.5 sq.ft.	Serving Sterling boilers		American Engineering Co.
3	Superheaters	Foster		On 400-hp. Wickes boilers	100 deg. superheat	Power Specialty Co.
1	Coal conveyor	Bucket	40 tons per hr.	Raise coal to bunkers		Link Belt Co.
1	Track scales	5 section	100 ton	Weigh incoming coal		Fairbanks Morse & Co.
1	Pump	Duplex	10x5x10-in.	Feed boilers	160 lb. steam	Henry R. Worthington
1	Pump	Duplex	14x8½x10-in.	Feed boilers	160 lb. steam	Henry R. Worthington
1	Pump	Duplex	10x7x15-in.	Feed boilers	160 lb. steam	Platt Iron Works Co.
1	Pump	Three-stage centrifugal	300 gal. per min.	Feed boilers	Driven by Kerr turbine	Jeanesville Iron Works Co.
1	Pump	Duplex	1000 gal. per min.	Fire pump	160 lb. steam	Henry R. Worthington
1	Heater	Receiver type	3500 hp.	Boiler feed water	Exhaust steam from aux.	Harrison Safety Boiler Works
2	Turbo-alternators	Alternating-current	2000 kw.	Main units	Two-phase, 60-cycle, 2300 volts, 1200 r.p.m.	Westinghouse Machine Co.
2	Condensers	Barometric	50,000 lb. steam per hr.	Serving 2000 kw. units		Alberger Pump & Condenser Co.
2	Pumps	Centrifugal	100 gal. per min.	Serving barometric condensers	Driven by Westinghouse vert. comp'd engine.	Alberger Pump & Condenser Co.
2	Pumps	Hor. dry vacuum	12x22x18-in.	Serving barometric condensers		Alberger Pump & Condenser Co.
1	Turbo-alternator	Alternating-current	6250 kw.	Main unit	Two-phase, 60-cycle, 2300 volts, 1800 r.p.m.	Westinghouse Machine Co.
1	Condenser	Surface	8000 sq.ft.	Serving 6250-kw. unit		Westinghouse Machine Co.
1	Pump	Centrifugal	8000 gal. per min.	Circulating cooling water	Driven by Westinghouse turbine	Westinghouse Machine Co.
1	Pump	Centrifugal	7-in. discharge	Air pump	Driven by Westinghouse turbine	Westinghouse Machine Co.
1	Pump	Centrifugal	6-in. discharge	Condensate pump	Driven by Westinghouse turbine	Westinghouse Machine Co.
1	Marine engine	Triple-expansion	17x27x46x30-in.	Main unit	160 lb. steam, vac. 26 in., 120 r.p.m.	S. F. Hodge & Co.
1	Generator	Induction	600 kw.	Direct connected to Marine eng.	Two-phase, 2200 volt, 120 r.p.m.	Stanley
1	Engine	Three-line triple-expansion	$13\frac{7}{16}$x$20\frac{7}{16}$x32x$13\frac{7}{16}$-in.	Main unit	160 lb. steam, 26-in. vac., 277 r.p.m.	Willans
1	Generator	Induction	600 kw.	Direct connected to Willans eng.	Two-phase, 2200 volt, 277 r.p.m.	Stanley
1	Condenser	Jet	50,000 lb. steam per hr.	Serving two 600-kw. units		Henry R. Worthington
1	Exciter	Eng. driven	60 kw.	Excitation of main units	Driven by 100-hp. Willans eng., 450 r.p.m.	Northern Electric
1	Exciter	Eng. driven	40 kw.	Excitation of main units	Driven by 100-hp. Willans eng., 325 r.p.m.	Northern Electric
1	Exciter	Eng. driven	60 kw.	Excitation of main units	Driven by 100-hp. Willans eng., 450 r.p.m.	Westinghouse Electric & Mfg. Co.

time and ability. The present board of commissioners includes J. J. Barlum, president; Charles H. Bryan, vice-president; J. T. Lynn, J. F. Lewis, Fred Guenther and George Burns.

⁂

Mechanical Scale Preventer

What has been designed to be a simple, practical, low-cost, automatic method of preventing scale formation in steam boilers is illustrated herewith. It is manufactured by the Mechanical Scale Prevention Co., 105 Chambers St., New York City.



SECTION THROUGH SCALE PREVENTER

The device consists of a tube *C*, at one end of which is the filter chamber *D*. This is made with a perforated plate next to the two flanges of the thimble. The space between the two perforated plates is filled with filtering material. The apparatus is placed in the top or the bottom of the horizontal return-tubular boilers or in the steam drums of water-tube boilers. It is in sections and no change in piping is necessary when putting it in a boiler.

The feed water enters through the pipe *A* and passes into the heater and settling chamber *C*, where the water is heated sufficiently to precipitate the solids. The water minus the impurities passes through the filter *D* into the boiler at nearly steam temperature.

As the preventer is in contact with water only, the solids do not bake or harden to the shell; they are removed through the blowoff *B*. This is done by closing the valve in the supply pipe *A* and by opening the one in the blow-down pipe *B*, which produces a reverse pressure on the filtering material and blows out whatever sediment has been collected by the filter in the precipitating and heating chamber *C*.

⁂

Large Testing Transformer—Two students of the University of Washington have undertaken the construction of what is said to be the largest testing transformer on the Pacific Coast, as a thesis for a degree in engineering. They are Leo Dashley and Joan Dodds, both Seattle men. The transformer, which will be ready for use in the spring, will be surpassed only by those in the testing laboratories of some of the big electrical companies. The apparatus is to be set up in the engineering building for research work and the testing of insulating materials. It will be 7 ft. high, 4 ft. wide and 2 ft. thick; will contain 300 lb. of wire; and will step up the voltage from 220 to 220,000.

The Power-Factor Indicator

By John A. Randolph

SYNOPSIS—Principle of the power-factor meter and its operation on single-, two- and three-phase circuits.

The power-factor indicator or meter is an instrument for obtaining readings of the power factor of a circuit together with an indication as to whether the current is lagging or leading. Such an instrument is necessary in stations equipped with alternating-current machinery in order that the excitation of the machines may be so regulated as to secure at all times the maximum efficiency in the operation of the system. They are also connected to feeders for an indication of the power factor on the various parts of the distribution system.

As ordinarily constructed, the power-factor indicator consists of two sets of coils. One set, called the current coils, is connected to the secondary side of one or more current transformers in the power lines; the other set, known as the voltage coils, being connected either directly across the lines or to the secondaries of potential transformers; the latter are always used on high-tension lines.

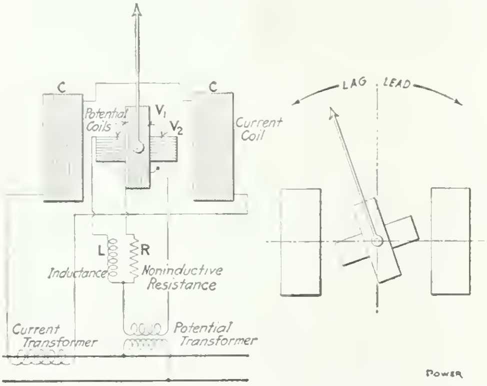


Fig. 1. Fig. 2.

Illustrating Principle of Single-Phase Power-Factor Meter

In one type of instrument the voltage coils are movable and are set upon the scale pointer shaft with axes in the same plane but at an angular displacement, depending upon the number of coils used. The shaft with its coils is free to move, inasmuch as it is not restricted by springs or weights. While the coils of the movable element are so arranged and connected as to produce a rotating field, the current coils are stationary and may produce either a fixed or rotating field, depending upon whether there is one coil connected to one phase or two or more coils connected to more than one phase.

Single-Phase Meter

The fundamental connections and elements of a single-phase instrument of this type are represented in Fig. 1, in which V_1 and V_2 are two voltage coils comprising the movable element. They are placed at right angles to each other on the pointer shaft. One of the coils, V_1, is connected across the lines or transformer secondary through a non-inductive resistance *R*, the other, V_2, being connected to the same source but through an inductance *L*. Inasmuch as the resistance *R* is noninductive, the current passing through V_1 will be in phase with the line voltage; that in V_2, however, will lag behind the line voltage owing to the inductance *L*. The latter is generally calibrated to cause the current in V_2 to lag 90 deg. behind that of V_1. As a result of this phase difference, the current in V_1 will be at its maximum when that of V_2 is zero, and *vice versa*. The resultant magnetic field of the two coils will rotate similarly to the field of an induction motor.

When the voltage is in phase with the line current, the magnetic field of V_1 will reach its maximum at the same instant as that of the stationary current coils *C*, the field of V_2 passing through zero at the same time. Moreover, when the field of V_2 is at its maximum, that of the current coils will be a minimum. No turning moment, therefore, will be exerted upon the voltage coils. However, when the line current is out of phase with the voltage, the currents in the coils V_1 and *C* will reach their maxima at different times. Furthermore, the current in V_2 will no longer be at zero simultaneously with the maximum of the current in coils *C*, but will exert a force upon the field of coils *C* depending in intensity upon the difference in phase between the line current and the voltage. The action of the field of the current coils upon the resultant field of V_1 and V_2 will serve to turn the latter away from the position shown in Fig. 1 to one such as shown in Fig. 2, the angle of deflection depending upon the lag or lead of the line current. The pointer at one end of the shaft of the movable element registers the extent of the deflection upon a scale calibrated to give direct readings either of the power factor corresponding to the deflection or of the phase difference in degrees between voltage and current. It also shows whether the current is leading or lagging by swinging to the right or left of the unity point on the scale. When the current in coil V_1 is in phase with the line current in coils *C*, the power factor of the circuit will be unity and will be so indicated by the pointer.

Polyphase Meter

The principle of operation for these instruments is the same as for the single-phase type. However, the arrangement and connections of the coils are different owing to the additional phases. No inductance is used for phase splitting in connection with the potential coils, inasmuch as the phase difference necessary for the rotating field of these coils is secured by connecting the latter directly across the line phases. The number and angular spacing of the potential coils depend upon the number of phases in the line circuit. On two-phase systems the potential element consists of two coils placed 90 deg. apart, whereas, on three-phase systems there are three star-connected coils placed 120 deg. apart. On balanced systems, only one current coil is necessary, but on unbalanced systems more must be used. On the unbalanced three-phase system three current coils are necessary in addition to the three potential coils in order that the variation in the strength of the line currents may be taken into account. In such an instrument, the fields of both sets of coils are rotating and their resultant effort on the movable element will cause it to move the pointer to a position corresponding to the power factor of the circuit as in the single-phase type.

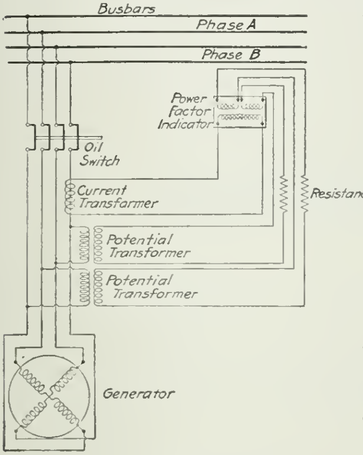


Fig. 3. Two-Phase Connections for Balanced System

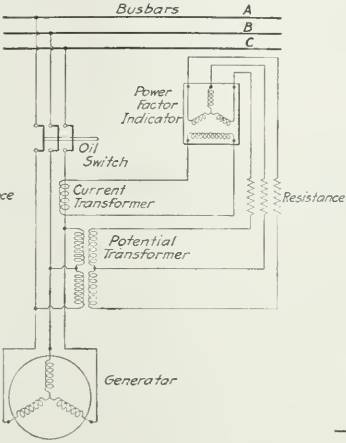


Fig. 4. Three-Phase Connections for Balanced System

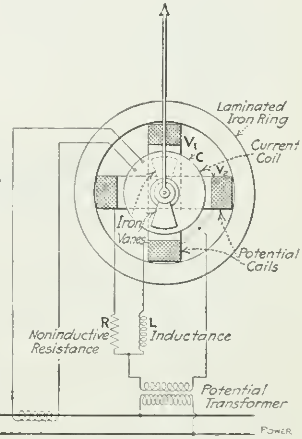


Fig. 5. Movable-Vane Type of Meter

Fig. 3 is a diagram of connections for a power-factor indicator on a two-phase circuit. It will be observed that there is but one current coil and that this is excited from only one of the phases, this being a common practice on balanced systems. However, on unbalanced systems such a connection would not give the average power factor of the circuit as a whole, but of only one of the phases. For that reason, for accuracy, it is necessary to use instruments with two or more current coils excited from current transformers so connected in the lines as to furnish an indication relative to the current flowing in all the phases. On systems whose load is made up of polyphase motors and converters, a balanced condition exists; therefore, on such circuits, power-factor indicators taking current from only one line are generally used.

A noninductive resistance is generally placed in series with each potential coil lead for purposes of calibration and current regulation. In Fig. 5 are shown the connections for a three-phase indicator as used on a balanced system.

MOVABLE-VANE TYPE

This instrument operates in a similar manner to these already described, but all of its coils are stationary. The movable element consists primarily of two iron vanes or armatures attached to the pointer shaft and extending radially in opposite directions as shown in Fig. 5. In the single-phase type there are two voltage coils V_1 and V_2, with axes at right angles to each other, and one current coil C whose plane coincides with that of the axes of the voltage coils. The connections of the voltage coils are similar to those of Fig. 1, one coil being connected across the line through a noninductive resistance and the other through an inductance, the currents in the two coils consequently being in quadrature. Therefore, the resultant magnetic field is rotary. Under the influence of the field of coil C, the iron vanes act as the magnetic poles of an electro-magnet and will therefore be turned in response to the action of the flux from the voltage coils V_1 and V_2.

If the line current is in phase with the voltage, the currents in coils V_2 and C will reach their maxima at the same instant, the current in coil V_1 then being at zero because of its set relation to that of coil V_2. The vanes will then take a position parallel with the axis of coil V_2 as shown, and the pointer will indicate unity power factor on the scale. If, however, the line current is out of phase with the voltage, the current in V_1 will no longer be at zero when that of C is at its maximum, but will have a value, at that instant, depending upon the phase difference between the line current and the voltage. It will, therefore, act with coil V_2 in exerting a turning force upon the iron vanes. The latter will be shifted to a point where equilibrium will be reached between the magnetic fields of the current and voltage coils, the pointer then indicating the power factor at this particular instant. The function of the laminated iron ring is to form a low-resistance path for the magnetic flux of the rotating field thus rendering the latter stronger and more efficient.

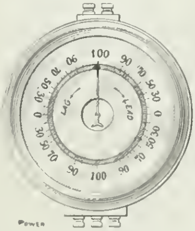


Fig. 6. Circular Dial Type

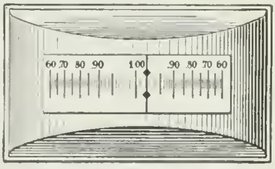


Fig. 7. Horizontal Edgewise Type

In the polyphase instrument of this type the positions of the current and voltage coils are interchanged from that shown in Fig. 5, the rotating field being then produced by the current coils instead of by those on the voltage circuit. In the two-phase meter there are two current coils which are placed 90 deg. apart, and in the three-phase instrument. the three coils are placed 120 deg. apart.

CONSTRUCTION AND INSTALLATION

The power-factor indicator is made in both the circular and horizontal edgewise patterns. the circular type being shown in Fig. 6. The directions which the pointer will take on leading or lagging currents are indicated by arrows marked accordingly. The scale gives readings from zero to one hundred. thus enabling any percentage of power factor to be read.

The horizontal edgewise indicator is shown in Fig. 7. The dial of the instrument is curved cylindrically, but the scale divisions are vertical and the pointer maintains a constantly vertical position. The pointer swings to right or left depending upon whether the current is leading or lagging, and the scale records power-factor readings from 60 per cent. to unity, this covering the range ordinarily encountered.

The resistances used in connection with the voltage coils of the various types are separate from the instrument and are usually in a convenient position on the back of the panel. They are contained in a small rectangular sheet-iron box so constructed as to allow free ventilation and ready access.

* *

Underfeed Stokers*

By Osborn Monnett†

SYNOPSIS—Headroom is the principal factor with these stokers. For smokeless operation no special brickwork is required. Their application to different types of boiler and instructions for operation are given.

*

The application of underfeed stokers to nearly all types of boiler is simple and no preparation in the form of arches or brickwork construction of any kind is required. Fig. 1 shows a 72-in. by 18-ft. boiler served by an American stoker. From the dead plate to the boiler shell the measurement is 42 in. With a similar boiler the standard height for Jones stokers varies from 36 to 42 in.

Fig. 2 is a typical installation of a Jones stoker and a return-tubular boiler. This stoker may be easily applied to a water-tube boiler when the baffles are horizontal. If desired, a T-tile can be used over the fire to any extent to increase the heat absorption. Fig. 3 shows such an installation consisting of an Oil City water-tube boiler and a Jones stoker; this arrangement is working out satisfactorily. The headroom in this instance is 6 ft. 3 in. from the floor line to the bottom of the front header and all the other dimensions are in proportion.

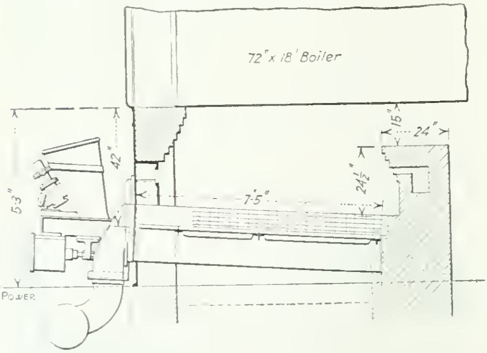


FIG. 1. AMERICAN STOKER UNDER RETURN-TUBULAR BOILER

In the case of a B. & W. boiler with a Sewell baffle, Fig. 4, a similar setting would be used, but, due to the pitch of the tubes, the headroom would be 7 ft. When using the vertical baffle, care should be taken that sufficient flame travel is provided to avoid the dampening effect of the tubes on combustion. As in other stokers, the bank of tubes has a wonderfully dampening effect on the flame; if set too close to the fire, the boiler will show considerable No. 1 and No. 2 smoke. On vertically baffled boilers of the B. & W. type using American or Jones stokers, 8 ft. 6 in. should be the minimum distance from the floor to the bottom of the front header. Fig. 5 is typical and shows the proper dimensions. There is nothing special to be said regarding the application of the Jones stoker to Stirling boilers; the setting may be made flush front and the standard Stirling arch can be used, as in Fig. 6.

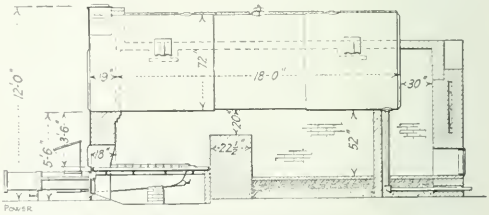


FIG. 2. JONES STOKER UNDER RETURN-TUBULAR BOILER

OPERATING AMERICAN OR JONES STOKERS

Starting Fires—Fill the retort by means of the ram so that the tuyere blocks are covered with green coal. Scatter fire from another furnace along each side and at the center of the retort on top of the green coal. Start the blower slowly. increasing the speed as the fire builds up. If steam is not available to work the stoker. fill the retort with scoops and start a wood fire on top of the coal in the usual manner, leaving the doors cracked open to prevent smoke. Fire by hand until steam is raised to work the ram and blower.

Carrying the Load—Always carry a thick fire on the retort, from 14 to 24 in. After the load is on, the operation is automatic and is taken care of by the steam pressure. When carrying a load, never throw in green coal on top of the fire as this will cause smoke.

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, City of Chicago.

Cleaning Fires—Clean the fires when the accumulation of clinker interferes with combustion. Lift the clinker from the dead plate with a slice bar and remove it through the front doors with a hook. Never clean so as to expose the dead plates to the intense heat of the fires. Let the ash and unconsumed coal remain on the side plates. Clean the dead plates and the top of the tuyere blocks only; the retort will keep itself clean. Shut off the forced draft when cleaning. Do not burn down the fire too thin before cleaning, and when cleaning, do not poke into the green coal as this will cause smoke.

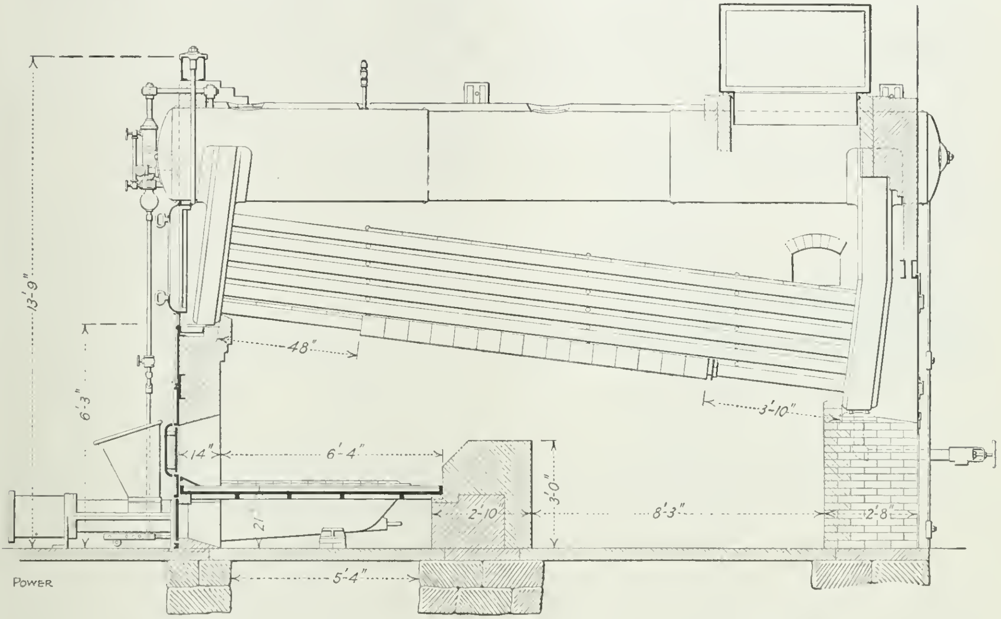

FIG. 3. JONES STOKER AND 130-HP. OIL CITY HORIZONTALLY BAFFLED BOILER

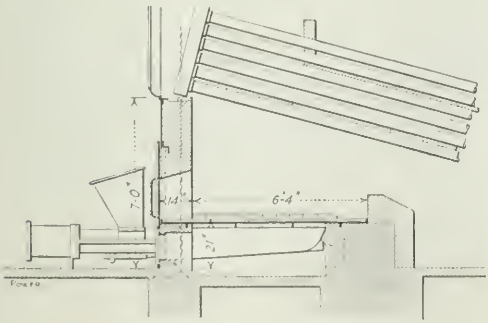

FIG. 4. BABCOCK & WILCOX BOILER, 131 HP., WITH T-TILE ROOF SERVED BY JONES STOKER

Banking and Breaking Up Fires—Introduce several charges of coal by means of the ram, shut off the forced draft and close the fire-doors and damper. If the bank has been on for a considerable period, some clinker may form in the retort. When starting up remove this clinker with a hook and break up the coked coal. The draft can then be turned on and the stoker started as usual.

TAYLOR STOKERS

This stoker is a development of the underfeed principle. There is a number of successful installations operating in the Middle West. While this stoker is not so well adapted to reconstruction jobs, especially where the boilers are set low, due to the headroom required for a successful installation, on a new job having plenty of headroom it is easily possible to get a good setting. Fig. 7 shows this stoker serving a B. & W. boiler set 9 ft. above the floor

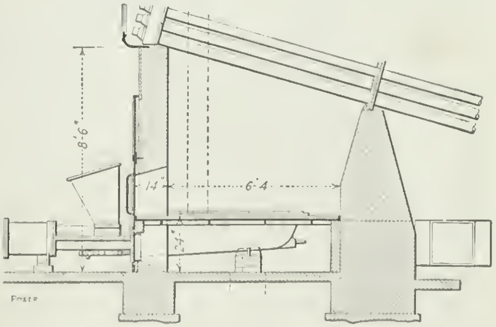

FIG. 5. JONES STOKER UNDER 134-HP. VERTICALLY BAFFLED BABCOCK & WILCOX BOILER

when measuring to the bottom of the front header. This outfit is running satisfactorily on Illinois bituminous coal. The flame travel is sufficient to allow thorough burning, and under loads up to considerably over rating the performance should be good. The capacity of the stoker to burn coal is limited only by the character of the refuse formed from that coal, and in turn the capacity of the stoker to free itself from this refuse. If the coal is such that the stoker can be run without working the fire from the side doors, there is little danger of smoke. The application of Taylor stokers to vertical boilers is simple. Fig. 8 shows a typical installation for a 500-hp. unit.

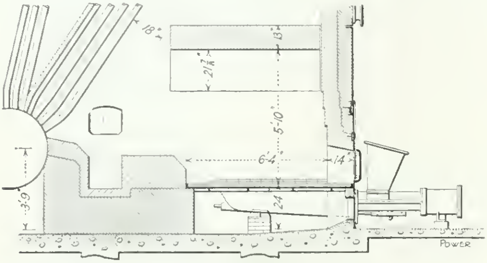

Fig. 6. Stirling Boiler, 500-Hp., Served by Three Jones Stokers

Operating Taylor Stokers

Starting Fires—Feed in sufficient coal to cover the top tuyeres, then shut down the stoker and build a fire on this coal along the front wall, using clean kindling wood or live coal from another fire. Let this coal become thoroughly ignited by natural draft, then begin feeding a little more coal slowly, using a little forced draft, and gradually increase the feed and air pressure as the fire builds up.

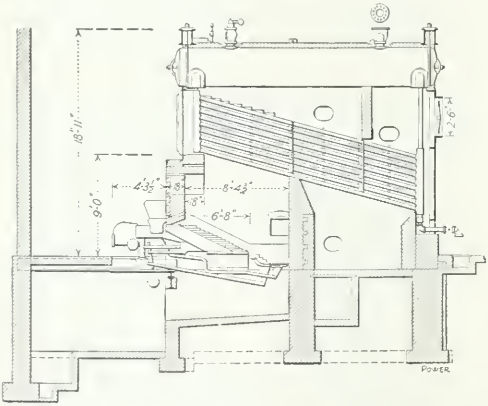

Fig. 7. Taylor Stoker under Babcock & Wilcox 250-Hp. Vertically Baffled Boiler

There is no need to work the fires by hand except possibly to clean an occasional clinker from the side walls. The best time to do this is on a banked fire; if carefully done, there is no occasion for making any smoke.

At the time of dumping there should be no green fuel on or just above the dump plates. If smoke is made when dumping, it is caused by dislodging coal which has not had its volatile entirely distilled. Therefore, dumping and cleaning out should be confined to that refuse which lies directly on the dump plates. Leave the blast on while dumping and do not disturb the rest of the fuel bed.

Banking Fires—The fire is not cleaned previous to banking. When banking, the air is shut off and the coal in the hopper is fed in, leaving the hopper empty. One hopper full of coal will ordinarily carry a bank from 36 to 40 hr. For longer periods, a small amount of coal is fed in from time to time. The ashes may be dumped during the banking period.

In starting from a banked fire, first dump the ashes and then start the stoker running for a number of revolutions with the hopper empty. This will force the accumulation of ash onto the dump grate and give a clean fire, upon which coal can be fed in the usual manner.

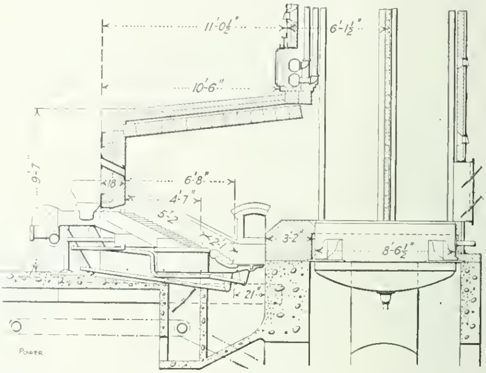

Fig. 8. Wickes 500-Hp. Boiler and Taylor Stoker

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Cement as Furnace Lining

To reduce the expense of boiler-furnace maintenance, the engineering department of the Robert Gair Co., Brooklyn, N. Y., has tried cement instead of firebrick or fireclay for lining the furnaces. The cement is of a 5 to 1 mixture of cement and hard-coal ash, with just a small part of sand, the latter being used sparingly, of course, because of the low temperature at which it melts.

The lining is 4½ in. thick on the side walls. The back arch is of concrete supported by T-irons, around which the concrete is poured. While one or two brick arches fell down, the concrete arches continue to give satisfactory service. In a neighboring plant settings of concrete were tried, but they failed.

It would be interesting if those who have tried cement and concrete for boiler settings would tell their experiences to Power readers.

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Power in Mining—The growing importance of mechanical power to the mining industry is shown by the fact that if mules alone were still relied on, the increased amount of power required in the last ten years would call for an additional investment of nearly eight million dollars in mules, not including replacing any that died during that period. As a matter of fact, the number of mules actually used decreased from 16,139 in 1902 to 15,187 in 1912, while the electric locomotives increased from 53 to 951 and the steam locomotives on the surface from 373 to 579.

Westinghouse Underfeed Stoker

An underfeed stoker has been developed by the Westinghouse Machine Co., Pittsburgh, Penn. It is designed to burn sufficient coal to evaporate three or more times the rated amount of water in a given boiler, and has been thoroughly tested in actual service. Its construction and operation will be understood by referring to Fig. 1, which shows the essential details.

Box girders *A* are bolted at their fronts to the ram boxes *B* and secured at their rear ends to a channel structure *B'* extending laterally across the furnace. These box girders support the plates *C*, which form the bottom of the retorts. Resting upon the top of each box girder are the grates *D*. These grates have an expansion joint between two sliding surfaces and the expansion space is further packed with asbestos at *E*.

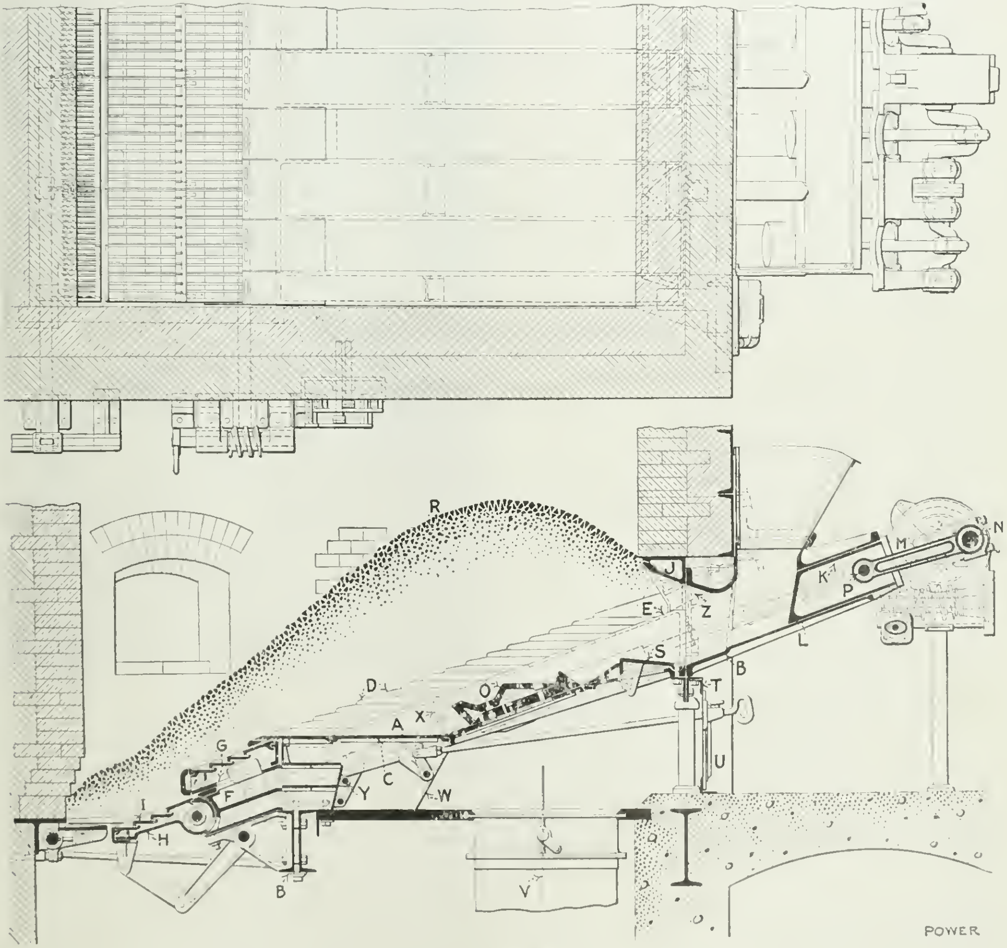

Fig. 1. Details of the New Westinghouse Underfeed Stoker

Bolted to the ends of the box girders are the brackets *F*, which form a support and air-supplying channels for the moving-grate sections *G*, and the dumping grate *H*.

The moving-grate sections reciprocate with a variable stroke between certain limits. The dumping grate is pivotally mounted on the brackets *F*. Between the bridge-wall and the end of the dumping grate *H* are secondary corrugated dumping-grate sections mounted on a shaft. The upper surfaces of the moving- and the dumping-grate sections consist of interchangeable corrugated grate bars *I*.

At the upper end of the box girders and extending laterally across the furnace are air-distributing boxes *J*, having a double row of nozzles for injecting air above the fuel bed. These boxes are bolted to the ram boxes *B*. The air-distributing boxes also form an expanding throat section for the coal fed into the furnace.

The fuel-feeding mechanism for each retort consists of a cylindrical plunger or ram *K*, having an inclined face *L*. The ram is connected by a rod *M* to a steel crankshaft *X*. The crankshaft is rotated through a double set of worms and gears driven from the speed shaft and sprocket, which, in turn, is connected by a chain to the main driving shaft.

The secondary pusher *O* is actuated through connecting-rods from the pin *P* and the stroke of the pusher is adjustable.

The moving-grate sections *G* are also connected to the pin *P* through suitable rods and reciprocate with an adjustable stroke in unison with the main plunger. The different crankshafts are set 90 deg. apart, thus distributing the load on the worm gears.

The stroke of the main ram is 12 in.; that of the secondary ram is generally three inches and may be varied from five to one inches, depending upon the condition of the fuel bed and the fuel used. The stroke of the movable-grate sections will vary from nothing to a maximum of three inches.

The dumping grate *H* is operated by a worm gear and shaft and levers through a ratchet at the side of the furnace. The bridgewall dumping grate is operated from the side of the furnace by a lever, and can be so adjusted that the ash is moved forward by the grate *G* and is continuously discharged. The position of the main dumping grate may also be adjusted to accomplish the same result.

The coal from the hopper is forced over the grates into a position indicated by the outline *R*, being deepest at the front portion of the fuel bed and gradually declining toward the rear. The fuel bed with varying fuel is maintained through the use of the relatively small incline of the stoker and the adjustable deflecting plate *S*.

The space under the grates is sealed by means of a reinforced-concrete floor and the front plate *T*, which carries the air-tight doors *U*, used for inspection and to admit air when the stoker is operating under natural draft. Under forced draft, the air is admitted through the main damper *V* and is further distributed in correct volume and pressure to the fuel bed through the damper *W*, which controls the air for the lower portion of the grates. A partition *X* in the box girder segregates the grates into two parts.

Air for the moving-grate sections is controlled by the damper *Y* from the side of the furnace. The air for the distributing box *J* passes through the connections *Z* and is controlled by dampers operated from a single shaft.

The absence of moving levers and links under the front of the stoker permits installation where there is restricted head room and where boilers are set relatively low and still maintain a large combustion space. The ash hoppers can also be separated from the boiler room as no levers or operating rods pass through them. This arrangement prevents ashes or gases from coming into the boiler room.

The fuel bed *R* is almost twice as thick at the front as it is at the rear of the furnace, and, therefore, the resistance to the passage of air is greatest at the front. Most of the volatile gases or hydrocarbons are distilled and pass through the fuel bed at the front, and as these hydrocarbons require almost three times as much air for combustion as does the coke, the importance of a large air supply at this point is apparent.

In this stoker the volume of air at the highest pressure employed for a certain rating enters under the front part of the stokers. The proper volume of air at a lower pressure is admitted to the lower end of the fuel bed through the dampers and is gradually decreased as it passes through the dampers for the moving and the dumping grates to suit the gradually decreasing thickness and combustible percentage of the fuel bed. The secondary air is diffused with a carbon monoxide gas above the fuel bed through jets arranged across the width of the furnace, and the air and gas are well mixed.

By this arrangement of introducing the correct amount of air at the necessary pressure and in the proper part of the fuel bed, less air is required per pound of coal, thereby increasing the furnace temperature and decreasing the stack losses due to excess air.

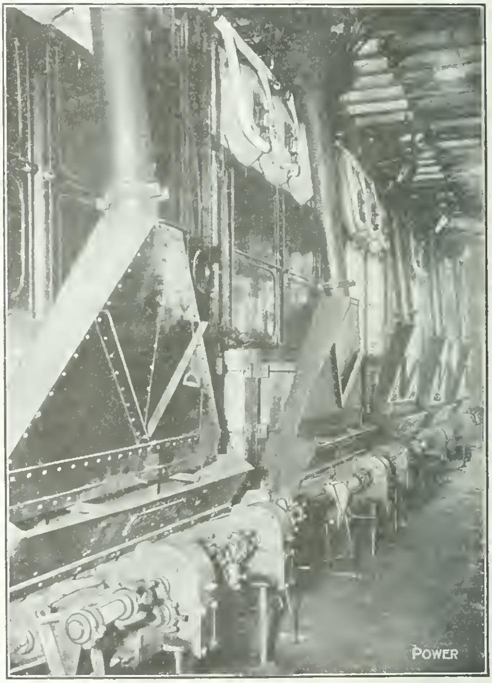

Fig. 2. Westinghouse Underfeed Stokers

The novel combination of an active grate under forced draft, which at the same time serves the purpose of a dumping grate, allows the installation of a maximum active grate area for high capacities inside of certain given furnace dimensions.

Through this control of four different parts of grate surface, the best rate of combustion per square foot of grate surface for a certain boiler rating can be maintained by operating the different dampers. For instance, at low ratings under forced draft the air may be closed off from the moving and the dumping grates. While these grates then serve only as a collecting surface, they may, with the demand for increased boiler capacity, be added as active grate surfaces. Thus the efficiency curve of the grate will be almost a straight horizontal line for boiler capacity varying between wide limits if plotted against the percentage of efficiency on a vertical line.

The stoker, attached to a battery of boilers, is shown in Fig. 2.

Equipment and Methods in Largest Refrigeration System--II

By Charles H. Bromley

SYNOPSIS—Interesting features of the largest refrigeration unit ever constructed. The machine is built for the unusually high speed of 75 r.p.m. and handles two widely different suction pressures. The builders were required to work to measurements in thousandths of an inch. Very fine pitch threads on the piston rods prevent them from backing out of the crossheads. The center crankpin is grooved circumferentially midway between the cranks so that, should it break, the machine will run as two side-crank engines. Hydraulic jacks are permanently located under both flywheels for raising the shaft.

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Features of the 1000-Ton Compressor

One thousand tons of refrigeration every twenty-four hours! And from one machine, in the Sargent's Wharf plant of the Quincy Market Cold Storage & Warehouse Co., Boston, Mass.

One ton of refrigeration capacity is the ability to absorb as much heat as will melt one ton of ice at 32 deg. F. into water at 32 deg. F.; the latent heat of ice at 32 deg. F. is 144 B.t.u. Then, with no losses, to freeze 1000 tons of water at 32 deg. into ice at 32 deg. F. requires

$$1000 \times 2000 \times 144 = 288{,}000{,}000\ B.t.u.$$

Suppose that the 25-lb. cake of ice your iceman puts into your refrigerator keeps it sufficiently cool for two days. One day's capacity of this machine would keep it cool for

$$\frac{288{,}000{,}000}{\frac{144 \times 25}{2}} = 160{,}000\ days$$

440 years continuously; or, if it were cooling ice boxes of this size, one day's capacity would keep 80,000 such boxes cool for two days. And one day's capacity is equal to the heat absorbed by the melting of a pillar of ice one foot square in section and 34,662 ft. high. This is nearly 46 times as high as the Woolworth Building, over 5600 ft. higher than Mt. Deodhunga in the Himalayas, believed to be the highest in the world; and, if the pillar could be pushed vertically to the greatest ocean depth discovered (31,614 ft. in the Pacific), it would rise above the surface 3048 ft.

The compressor weighs about 1,000,000 lb. and there is approximately 15 tons of bronze in the bearings. Thirty-five cars were required for its shipment. The foundation weighs about 2,500,000 lb. and contains over 800 yd. of concrete anchored to a mat which rests upon steel caissons driven into the blue clay and filled with concrete.

Judging from the performances of the other machines—the 800- and the 400-ton—Mr. Fairbanks, chief engineer for the company and designer of the compressor, feels confident that he can produce refrigeration with the 1000-ton machine for 20 cents per ton, which includes pumping the brine. With the 800-ton compressor the cost is 25 cents per ton. These costs do not, of course, include the overhead charges.

The 800- and 400-ton machines were heavily overloaded and the continually increasing demands called for an unusually large machine to relieve the overloaded ones and serve for future growth. Nearly all the land the company owned was already occupied, so a 1000-ton machine was decided on to occupy the engine-room space available after moving a large brine pump. Many of the compressor builders were consulted, but none cared to construct the machine according to the specifications, which required its making a speed of 75 r.p.m. This speed is much higher than large compressors are run; 40 r.p.m. is considered high and is usually utilized for short periods only. Ammonia-compressor speed is dependent primarily on the rapidity with which the ammonia valves will open and close successfully; therefore, the design of these valves, to be taken up later, is interesting.

When the specifications were drawn and all the drawings were completed, the Farrel Foundry & Machine Co. of Ansonia, Conn., started making the large castings and the Providence Engineering Works did all the machine work. The builders were required to work to measurements in thousandths of an inch. Wherever possible, a reasonable leeway, above or under or both, was permitted. Although at first the workmen were annoyed by being held down to such narrow limits, they later expressed their approval of the practice and the designer heartily commends the builders for so successfully meeting the specifications. Although the machine was not erected before being assembled on its present foundation, every part fitted without alteration.

While the plant's drafting force consists of three draftsmen, several additional men were obtained from the builders to assist in drawing the plans, a charge of 70 cents per hour per man being made. Skeleton patterns were used and, as they were ready to be drawn from the molds, the designer was notified and visited the Farrel Foundry & Machine Co. to inspect the mold before the pouring was done. This was a wise precaution, because if slight changes in the mold were desired the designer could instruct the molder to allow for slightly more or less thickness here or there. The molder could do most of this finishing with a trowel. The use of skeleton patterns was a big saving, for if the usual type patterns had been used they would have cost about $3500 more.

All yokes are of openhearth cast steel instead of cast iron as is usual. Ordinarily, crankpins are made of comparatively low-carbon steel and are case-hardened, but the crankpins of this machine are of 0.15 carbon steel, annealed.

Experience with both of the other machines—they had bedplates of usual weight and strength for all stresses—proved that they were insufficiently reinforced transversely to be absolutely safe against fracture under all normal conditions of stress imposed by the continuous service. The bedplate of the 400-ton compressor, for example, broke three times in the same place, namely, in the middle between the A-frames and immediately under the shaft housing. Now all bedplates, including that of the 1000-ton machine, are reinforced about three times as much as in common practice, for a fractured bedplate is serious and long shutdowns here are out of the question. It was near the end of a busy season when the bedplate of the 400-ton machine last let go. Only the two machines were available then, for the 1000-ton compressor had not then been built. It was dangerous to run this already overloaded machine in this condition, but the exigencies of the service demanded that it be done for weeks or until the load dropped.

These were not the only fractures in this plant, and experience here and in other places leads one to conclude, notwithstanding all that has been said and done about it, that designers would do well to continue giving more consideration to the effects of fatigue in parts of machines in nearly constant service or likely to experience such service, and make greater allowances for it.

FINE-PITCH THREADS FOR PISTON RODS AND OTHER PARTS

United States standard screws have eight threads to the inch for a 1-in. diameter screw, 4½ for a 2-in.; 3½ for a 3-in.; 3 for a 4-in.; 2½ for a 5-in.; and 2¼ for a 6-in. Engine builders, however, usually use threads of a little finer pitch for such parts as piston rods, plunger rods, etc.

Here again experience showed the necessity of going common practice one better if accidents and shutdowns due to piston rods backing out of the crossheads were to be made remotely possible. The threads must be of a much finer pitch so that after a nut was set up and driven home with a hammer blow on the wrench, it would stay tight. The piston rods of the new compressor were given threads of finer than usual pitch—the 6½-in. rod having 6-in. threads to the inch—and, as the rods in the other machines are renewed they too will be so threaded.

As an additional safeguard against rods backing out, a screw with a large round head is put into the piston rod near the crosshead after the rod has been screwed in as tightly as possible. The engineers and oilers are instructed to watch and feel these screws as they make their regular rounds. If the head of the screw is above or below a horizontal line through the center of the rod, the attendants know that the rod is backing off or screwing in. Soft-steel washers are used under all nuts such as those for the foundation, frame and flywheel bolts. To avoid troubles due to the expansion of foundation bolts of unequal lengths, which sometimes puts serious stresses on parts of the bedplate, Mr. Fairbanks provided for bolts of equal length.

MAIN BEARING SHELLS BORED IN POSITION

After the bedplates were erected, the foundation grouted and the cement thoroughly set, the bedplates were pulled into position by 56 foundation bolts, each of 3 in. diameter and 14 ft. long. The jaws carrying the main bearing shells were next bored in position with a bar to insure perfect alignment of the shells. The specifications called for a deviation of not over 0.002 in. Micrometer measurements showed that there was a deviation of only seven-eighths of 0.001 in. All bearings are of specified bronze with diagonal babbitt inserts in the larger ones. The takeups are of the draw-wedge type, with double capscrew lock. There are 15 tons of bronze in these bearings.

JACK UNDER FLYWHEELS TO LIFT SHAFT

Everyone who has had to stop an engine because of a hot main bearing and scrape and fuss with the bearing before the machine could be put back in service, knows that considerable delay is occasioned. To avoid this at the Sargent's Wharf plant the bearing shells are in duplicate and turned within 0.002 in. of each other. Should a hot bearing fail to be cooled by even refrigeration-plant methods, and a shutdown results, the bearing caps may be removed and the shaft and connected parts raised by permanently located hydraulic jacks, one under each of the two flywheels. The hot brasses may then be lifted out and cool ones inserted.

These jacks are, of course, a convenience and undoubtedly save time, but on account of the size of the machine it would take about four hours to remove all caps, replace the hot with cool shells and get the machine back into service. Here is where the deflection of the main shaft proves valuable.

DEFLECTION OF THE MAIN SHAFT

This shaft is 24 in. in diameter by 26 ft. long, has a 7-in. hole through the center and is of 0.45 carbon, fluid-compressed, openhearth steel with a tensile strength of 90,000 lb. per sq.in. While measuring the deflection of the shaft with disk micrometers, a valuable discovery was made. (Bear in mind that it would require about four hours to put new brasses in a bearing.) While measuring the deflection between No. 3 bearing and No. 4, or the outboard bearing (the jack or load on the shaft being applied at No. 4), it was found that the micrometer at No. 4 showed a deflection of 0.019 in. before the instrument at No. 2 began to show any deflection, but 0.011 in. deflection liberated the bearing shells. So, if ever it becomes necessary to quickly put new brasses in either of the outboard bearings, the cap of the affected bearing only need be lifted and the shaft raised with a jack until the brasses are free to be pulled out. Although there is considerable deflection between two bearings, it might be found that when the brasses were hot they could not be relieved by the jack until the cap on the next bearing was loosened a trifle, but this would occasion no appreciable delay.

MACHINE TWO SIDE-CRANK ENGINES IF CENTER CRANKPIN BREAKS

The cranks are of 0.35 carbon openhearth cast steel and the connecting-rods of 0.45 carbon openhearth forged steel; the crankpins also are 0.45 carbon steel annealed. The center crankpin (the compressor has three vertical ammonia cylinders and two horizontal steam cylinders) has a groove ⅛ in. wide by ¼ in. deep in the circumference of the pin midway between the cranks. In case of serious stress from any abnormal condition, the pin would presumably break in the groove, thus leaving the two sections of the pin in their respective cranks, and allowing the compressor to be run as two side-crank engines.

The next and third article of the series deals with many other points of interest about the 1000-ton compressor.

Will Quizz, Jr.

SYNOPSIS—Chief Teller, following the discussion of the barometer, gives Will *a line on the manometer.*

*

"The other day, Will, we discussed the barometer. There is another meter which is equally interesting, called the manometer, or, more familiarly, a pressure gage."

"Gee, Chief, a manometer must be a gage with a college education to have a name like that."

"After all, son, in its simplest form it is just a U-tube with any liquid inside—usually water for low pressures and mercury for higher. With the U-tube partly filled, any pressure exerted on one side will depress the liquid in that side and drive it up in the other. Don't you remember? We used it in the discussion of heating piping some time ago" (p. 51, July 14).

"You are familiar with draft and blower gages having water in them, so we will pass to the mercury tube and see what may be learned from it.

"To begin with, if we put mercury into a rather long U-tube and connect one side to a boiler or other source of pressure, the mercury will be depressed in one side and driven up in the other. You will remember that a column of mercury 30 in. high, at the level of the sea and under ordinary atmospheric conditions, will exert a pressure of 14.7 lb. Therefore, the difference in the level of the mercury in the two sides of the U-tube indicates the pressure being exerted on the one side more than on the other. This difference in the level in inches, Fig. 1, multiplied by 0.49001 or mulitplied by 14.7 and divided by 30, is resolved into pounds pressure. Or, as our foreign friends often express it, each 30 in. equals so many atmospheres, plus one, for there is always one atmosphere acting on the open side. This furnishes an accurate method of testing steam gages and indicator springs, but, in this case again, we must consult the barometer.

"Another form of manometer has the tube closed at the top and as the mercury rises in that side it compresses the air in the tube. Therefore, it does not require such a high column of mercury. The air trapped in the tube follows a definite law, known as Boyle's or Mariotte's law, which is expressed by the $P \times V = C$ formula. Get this formula fixed in your mind, Will; I got started on this subject for that purpose. This law enters into the study of the action of steam in an engine cylinder or of air in a compressor—in fact, it is one of the laws most frequently met with in the study of gases under pressure."

"What does this law mean, Chief, and how was it established."

"In 1662, Robert Boyle, an English physicist, and, independently, in 1679, Edme Mariotte in France made experiments and came to the same conclusions; namely, 'The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure it bears.' There are slight variations at extreme pressures and with different gases, but for practical purposes they need not be considered.

"The law is known in England as Boyle's Law and on the Continent as Mariotte's Law; in this country by either or both names.

"It means that when a given volume of gas is compressed into a space of one-half the volume and the temperature is kept the same as before, it will have double the pressure it had at first, or, if allowed to occupy double the space, it will have only one-half the original pressure. The temperature remains the same, remember. If, one at a time, such facts can be made to stick like a burr, it won't be lost nor will the time be ill spent."

"But, Chief, do not air and all other gases get more heat when compressed?"

"The heat of compression you refer to is not that the gas gets more heat than it had, but that the total heat, of a cubic foot for example, is compressed into a much smaller space. That is a subject we will talk about some other time, not to get off this present one. In this experiment the heat incidental to compression must be removed and the temperature brought to the same degree. The illustration will give you the story. (Fig. 2.)

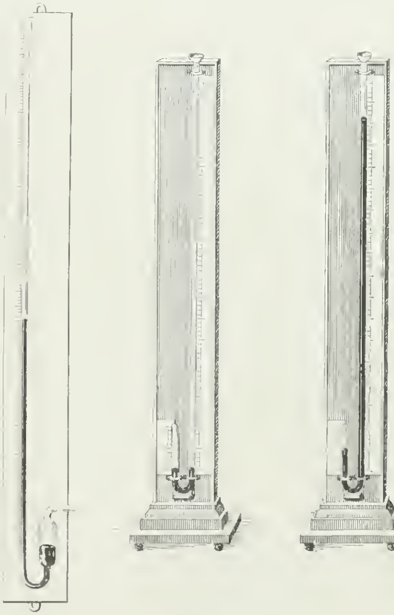

FIG. 1. FIG. 2. FIG. 3.

MERCURY MANOMETERS

"The short end of the tube is closed and the other is open. With just enough mercury poured in to fill the tube at the bend, it is evident that the air in the short side will be at the same pressure as the other—14.7 lb., or one atmosphere—and the mercury will be at the same level in both. If, however, more mercury is poured into the long tube it cannot rise in the short tube except as it compresses the air somewhat. If we continue to pour in mercury until there is a difference of 30 in. between the heights of the mercury in the two sides, it will be found that the mercury in the short tube has risen half way between the first mark and the top of the short tube. Therefore, as the air in the short tube is sustaining an unbalanced column of mercury 30 in. high, it has a pressure of 14.7 lb. above the atmosphere, or two atmospheres in all, and it occupies a space just one-half as great as originally." (Fig. 3.)

"Will the space the air occupies be reduced one-half again if 30 in. more of mercury is poured in?"

"No, Will, whatever pressure there may be on the air must be doubled in order to compress the air into one-half the space. Therefore, to get it compressed into one-half the space and have the pressure consequently doubled, it is necessary to put in twice the height of mercury next time—that is, 60 in. more, making 90 in all, above the level in the short tube (not above the original level).

"You see, the air will occupy a fourth of the original space and have four times the pressure, or four atmospheres, three of which will be due to the 90-in. head of mercury and the fourth to the air pressure on top of it in the long open tube. So, this is the $P \times V = C$ formula, which is the short statement of this law, where P = pressure, V = volume and C is the constant quotient when the two variables are multiplied together. The same law applies to the expansion of gas, so if the space or volume be increased the pressure will be reduced as a result. For an every-day example, take the expansion of steam in the engine cylinder after cutoff and in the other way to the air in the compressor cylinder. At some future time we will take up the application of this law to our own plant."

* *

Why the Isolated Plant Should Win

By Henry D. Jackson

SYNOPSIS—An analysis of central-station costs, showing that while the actual switchboard cost is low, the overhead charges, losses and distribution expense bring the total cost far above that in the isolated plant, providing the latter is operated efficiently.

*

At a gathering of engineers recently, one said that the time was coming when every large city would have but one central plant for heat and power. He based his argument on the value of concentration as regards the cost of generation and distribution of power.

That such is the trend so long as the central stations are controlled as at present, cannot be denied; but that such is not the logical trend if such plants are regulated for the benefit of the people at large and not for the few, the writer believes, cannot be denied.

The large central plants can and do produce power at the switchboard at prices below that attainable by most of the isolated plants under the present system of construction and operation. This is due to a number of things among which are:

1. The generating units are large and designed for the most efficient operation.
2. Careful operating methods are employed.
3. There is every refinement in the plant to gain low operating cost.
4. The boiler room is carefully watched and every step is taken to secure the utmost results from the coal.

All of these result in very low operating costs and, therefore, in a low cost of power at the switchboard; but many of them add largely to the fixed charges, which must not be lost sight of.

Few of these refinements are worth while in an isolated plant. The size of the unit is dependent on the power required and, to a certain extent, the economy of operation may have to be sacrificed somewhat. This depends largely on the conditions, which often call for a comparatively inefficient unit, so far as steam consumption is concerned, owing to the value of the exhaust steam for other purposes. Therefore, it is often advisable to purchase a moderate-priced unit, inefficient in steam, but efficient as concerns the whole plant, owing to the reduction in fixed charges.

As for operating methods, there is no reason why a small plant should not be as carefully operated as a large one. Refinements of this nature can be made in an isolated plant just as well, providing they are warranted by the resultant gain. It is in the boiler room where most of the isolated plants fall down and where the greatest gain can be made by proper supervision. The cost of coal is about one-half the total cost of power at the switchboard, even in the large plants, and this may reach a large proportion of the total costs in other plants.

The coal that is wasted in the majority of isolated plants is astonishing. It is not uncommon to find plants using high-grade coal, ranging from 13,500 to 14,000 B.t.u., with an evaporation in the neighborhood of six pounds, even with hot feed water. This unquestionably results from improper firing, a poor condition of the boilers, and possibly such causes as poor boiler settings. By far the greater cause is that no steps are taken to measure the water fed or to weigh the coal; hence, neither the fireman, engineer, nor owner has any idea from day to day as to what the boilers are doing. The only thing the owner knows is that his coal bills are steadily going up, although the plant output may be holding constant. Arguments by the engineer or fireman for the installation of scales and meters are frequently of no avail. These cost money, and the owner either cannot or will not see that money spent here will return larger dividends than that spent in almost any other part of the plant.

Central stations, on the other hand, in order to obtain low production costs, install meters and scales wherever they will show valuable results, and recording or indicating devices to show the condition of the furnaces and what the boilers are doing; until at present the fireman has at his service far more devices to show what is going on than the engineer. This is economy.

Unless the boilers are kept clean, there will be an increase in the coal necessary to evaporate the water; unless the coal is properly fired, much will be wasted; unless the dampers are properly regulated, a large part of the heat will go up the stack or much of the coal will not be completely burned; and unless the feed water is properly regulated, the steam pressure will fluctuate. Therefore, it will be seen that the fireman, who is poorly paid as compared to the engineer, is responsible for far more value than is the latter for he can in many cases waste more than his wages every day without its being apparent, unless adequate records are kept.

In most plants, it may not be necessary to install all, or even a small part, of the boiler-room devices available; but meters to measure the water, scales to weigh the coal, thermometers to determine the temperature of the feed water, and feed-water purifiers, in case the water is bad, are essential features for economical results. In addition, CO_2 recorders and steam-flow meters are valuable adjuncts and will help to keep down the costs. Every big plant has these devices, and every day more of them are being used in the smaller plants.

Consider, for instance, a 500-hp. plant utilizing 15,000 lb. of steam per hour in a 10-hr. day, with an evaporation of 10 lb. This would represent 15,000 lb. or 7½ short tons of coal per day. At an evaporation of 5 lb., it will represent 15 tons per day. With the coal costing \$4 a ton, an evaporation of 10 lb. would represent \$30 per day against \$60 with an evaporation of 5 lb. This is an extreme case, to be sure, but it illustrates to a marked extent what is often done as compared to what might be attained. The difference of \$30 in one day will go a long way toward paying the interest on the devices necessary for measuring the water in an isolated plant of 500 hp. and every other day will pay a large dividend on the investment, part of which could well be spent as a bonus to the fireman for keeping up the good work.

One might be led to ask: What has this to do with the central stations? It has this to do with them. Central stations, as a rule, could not compete with isolated plants if the plant owners would attempt to operate their plants as the central stations are run. If the plant owners would put the same amount of energy and care into operating their plants that they put into the operation of other departments of their factories, there need be no fear of central-station competition.

Attention has been called to the cost of coal as approximately one-half that of power at the central-station switchboard, and for this reason the managements have put an enormous amount of energy and money into reducing their coal bills. It might be equally instructive if attention were called to the fact that the cost of power at the central-station switchboard is but a small item in the total cost of power as delivered to the customer, for the central station, owing to its high investment, has exceedingly heavy fixed charges.

It is a common belief that in central stations the investment per kilowatt of capacity is low, owing to the large units. Many large central stations carry their plant values on their books, exclusive of real estate, at approximately \$110 per kilowatt. This is far higher than would be the cost of a moderate-sized isolated plant, including the real estate and building, which can be installed for about \$100 per kilowatt, with every refinement necessary or desirable for the most efficient operation. Thus, the fixed charges on the central station should be as heavy and, in fact, heavier than those of the isolated plant per kilowatt of installation; and as the central-station units run but a comparatively short time at full load, the actual fixed charges per kilowatt-hour are far greater than in the case of the average isolated plant. This covers only the power plant. In the isolated plant, the fixed charges cease here. In the case of the central station, however, there must be added the fixed charges on office buildings, transmission lines, transformers for distributing, meters for recording, and other incidental apparatus required for carrying on the business. Thus, the fixed charges become a large item in the cost of power as delivered.

The power when it reaches the isolated-plant switchboard has reached the end of its cost, for, in comparing its cost with that of purchased power, it is at this point that the central-station power charge begins. In the case of the central station, however, when the power has reached the switchboard, its cost has but just begun. This power must be distributed, and many times it has to be carried miles before it reaches the customer. There is a heavy loss over these lines, also in the transformers and meters, and the plant itself uses a large amount of power for advertising and other purposes; so that the power actually delivered to the customers ranges from 70 to 75 per cent. of the power generated at the station. Thus, the power cost at the station must be increased by the time it arrives at the consumers' premises by 25 to 30 per cent., in order that it may cover the actual cost to the central station. This is for line or transmission losses alone.

The transmission lines must be added to from time to time, and replaced and maintained, which is expensive. The general handling of the business details of the central station is also expensive, for the meters must be read, their readings returned to the office, checked, the cost made out and bills rendered and collected; the plant or plants must be supervised, the officers' salaries must be paid, and all the details of a large office and engineering organization have to be accounted. Moreover, a central station must pay taxes, as any other business. In addition, there are a number of incidentals not enumerated, together with interest on the investment, covering the plant, real estate, lines and all the apparatus necessary for the carrying on of a central-station business. These items, based on a kilowatt of output, are invariably several times the actual switchboard cost. On an average, the cost at the switchboard will be about one-sixth that as actually delivered to the customer. This being the case, it is hard to see wherein a central station can compete with an isolated plant if the isolated plant is operated with the same attention to detail as is the central plant.

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The British Thermal Unit—One B.t.u. is the quantity of heat required to raise the temperature of one pound of water one degree. As a gallon of water weighs 8⅓ lb., it requires 8⅓ B.t.u. to raise the temperature of one gallon one degree, or 16⅔ B.t.u. to raise the temperature two degrees, and so on.

Thus, when a given coal is said to have a heat value of 13,800 B.t.u. per lb., it is meant that if all the heat caused by the complete combustion of one pound of that coal could be transmitted to 13,800 lb. of water it would raise the temperature of that water one degree. Or, if all the heat could be transmitted to, say 138 lb. of water, it would raise the temperature of that water just 100 deg., because

$$138 \times 100 = 13,800$$

The pounds of water heated multiplied by the number of degrees the temperature has been raised equals the number of B.t.u. The standard method of finding the heat value of a fuel is to burn a small sample of it in a tight steel bomb under water. The heat caused by the burning of the sample is then all absorbed by the water and by multiplying the weight of the water by its rise in temperature and dividing by the weight of the sample, the heat value of the coal is calculated direct in B.t.u. per pound. Thus, if we burned a small sample weighing one-five-hundredth of a pound in a bomb immersed in 5 lb. of water, and if the temperature of that water increased from, say, 70.4 deg. to 75.92 deg., a rise of 5.52 deg., the heat value of the coal would be

$$\frac{5 \times 5.52}{0.002} \quad 13,800 \text{ B.t.u. per lb.}$$

The Nicholson Furnace

Consisting of a set of hollow grate bars, a forced-draft outfit and galvanized-iron ducts connecting the fan with the ashpit, the Nicholson furnace has been recently placed on the market to increase the capacity and efficiency of a boiler over results obtained with natural draft and hand-firing. It is especially adapted to burn slack and cheap grades of coal efficiently, due to the thorough mixing of the air with the products of combustion.

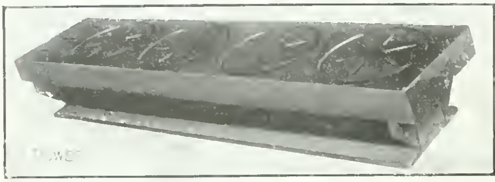

Fig. 1. Nicholson Grate Bars

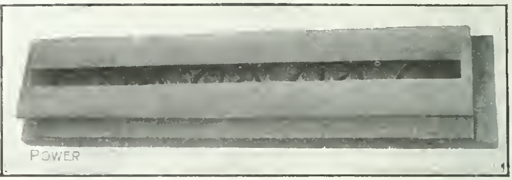

Fig. 2. Bottom of Bar

The grates are hollow cast-iron bars of the general shape indicated in Figs. 1 and 2 and are made in sizes to fit the furnace. The depth of the bar is about 6 in., the width varies from 8 to 9 in. and the length is decided by the furnace. As no change in setting is necessary, the grate may be easily adapted to old boiler plants. As shown in Fig. 3, the grates are placed side by side on the rest bars of the former furnace or on the bars of a new installation. A mixture of fireclay and cement is filled in between the bars and around the sides so that no air can enter the furnace except through the circular and radial slots shown. These slots are all cut at an angle so that the air is thoroughly diffused and forced to every part of the fuel bed. The jets of air meet and mix with the fuel gases instead of passing directly upward through the fuel bed. The air space forms only 8 to 10 per cent. of the grate surface, but an air pressure of ¾ to 1 in. of water in a sealed ashpit insures the passage of sufficient air through the slots to burn the coal. Due to the design of the bottom of the bar and the restricted openings, an equal distribution of air over the whole grate surface is insured.

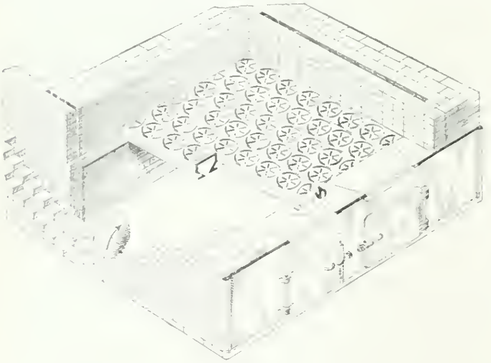

Fig. 3. Bars Placed in Furnace

As the slots are at an angle, and narrow at the top, it is difficult for small particles of coal to fall through against the air pressure, and as the openings are larger at the bottom there is little tendency to clog. The proportions of the bar and the hollow construction present a large cooling surface to the air, which tends to keep the grates cool and prevents clinkering.

The fan is located centrally with a flue to each ashpit. The speed of the fan may be controlled by the throttle, or automatically, and a damper in each flue permits individual adjustment.

On tests made on a horizontal tubular boiler and Nicholson furnace at the Rock Island water-works, the results given in the accompanying table were obtained with inferior grades of coal. The maker of the furnace is the Improved Combustion Co., 445 Peoples Gas Building, Chicago, Ill.

DATA AND RESULTS OF EVAPORATIVE TESTS

	Kind of Fuel			
	(1) Franklin Co. 2-In. Screenings		(2) Matherville (Mercer Co.) 2-In. Screenings	
Duration of trial, hr.	10		10	
Grate surface, sq.ft.	58		58	
Water heating surface, sq.ft.	2980		2980	
Av. corrected steam pressure, lb.	109.4		109.6	
Av. temp. of external air, deg. F.	3.5		16.2	
Av. temp. of fireroom	59		60	
Av. temp. of feed water, deg. F.	150.8		148.6	
Prox. analysis of coal—	Dry Coal	Combustible	Dry Coal	Combustible
Fixed carbon, per cent.	52.8	60.9	37.1	50.3
Volatile matter, per cent.	34.05	38.1	36.9	49.8
Total moisture, per cent.	9.0		12.5	
Ash "dry coal," per cent.	13.15		25.0	
Sulphur "as received," per cent	1		6.0	
Dry coal per sq.ft. grate surface per hr., lb.	10.58		12.9	
Calorific value by Parr calorimeter "dry coal," B.t.u.	12,247		10,216	
Horsepower developed	162		172	
Builders' rated horsepower	300		300	
Water evap. per lb. of coal under actual conditions, lb.	7.5		6.26	
Equiv. evap. f. and a. 212 deg. F. per lb. of wet coal, lb.	8.3		6.95	
Equiv. evap. f. and a. 212 deg. F. per lb. of dry coal, lb.	9.13		7.95	
Equiv. evap. f. and a. 212 deg. F. per lb. of combustible, lb.	10.5		10.60	
Efficiency of boiler, per cent.	72.0		75.0	
Cost of coal per ton delivered	$1.975		$1.40	
Cost of fuel used for evap. 1000 lb. of water f. and a. 212 deg. F.	$0.1186		$0.1008	

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Nitrogen Lamps Under Varying Voltage—An experiment was performed recently with a 400-watt gas-filled nitrogen lamp rated at 110 volts, for the purpose of finding the behavior of the filament when subjected to low voltages. The results were as follows: Barely red at 9 volts; bright red at 20; very red at 30; white at 40; dazzling white at 50, and blinding white at 110. It would appear from this that the fluctuations in voltage will be less apparent with the nitrogen lamp than with the old style lamps.

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The Efficiency of the Electric Generator is the ratio of the useful output to the total input, or letting

E = Total energy used in driving the generator;
E′ = Energy available at terminals of the machine;
e = Total losses.

$$\text{efficiency} = \frac{E'}{E} = \frac{E'}{E' + e} = \frac{E - e}{E}$$

The efficiency of ordinary alternators varies from 90 to 95 per cent. The losses consist of windage, bearing and brush friction, iron losses and copper losses.

Editorials

New York City's Refrigerant Regulations

On January first the regulations of the Fire Prevention Bureau of the Fire Department of New York City governing the use and handling of refrigerants go into effect. These regulations are printed on page 862 of this issue.

Engineers, manufacturers—all seem to have learned only recently that the real solution to the boiler inspection, specification and operating problem was a national code such as was formulated and approved at the recent annual meeting of the American Society of Mechanical Engineers. The rules that should govern the local use of refrigerants may with equal benefits be approved by users nationally.

Escaping ammonia gas is just as dangerous in Milwaukee as in Boston, New York or Richmond. Yet New York and Boston, each conscious of the necessity of regulating the disposition of refrigerants, simultaneously started out to investigate and to formulate and apply such regulations. Did they coöperate? No; that would be too unusual. We doubt if either city realized that each had ammonia machines in its confines.

What is the result? On January first New York City will put into effect a set of regulations some of the sections of which are said to be objectionable if not dangerous. This is demonstrated by the Massachusetts Board of Boiler Rules in its investigation of the dangers attendant upon the handling of refrigerants.

For example, section two of the New York regulations calls for a pipe to lead escaped ammonia gas into water or to continue the outlet pipe at least ten feet above adjacent buildings. At the recent annual meeting of the American Society of Refrigerating Engineers, it was pointed out that, although the Massachusetts Board of Boiler Rules, assisted by prominent engineers and professors of engineering, had made investigations into the disposition of escaped ammonia gas, as from compressor heads and condensers through safety valves and piping, these authorities were by no means satisfied with any of the methods in use.

The use of pop safety valves for such service was condemned because they opened too suddenly, quickly liberating too much gas. A valve that would begin to blow at about twenty-five pounds below the pressure at which it was set to open was necessary to give the operator warning timely enough to allow him to take steps to reduce the pressure.

There is need for uniformity of regulations for the handling of refrigerants. Trouble may be expected when the New York City rules are applied.

The American Society of Refrigerating Engineers has not discharged its regulations committee. The American Society of Mechanical Engineers has just been through the experience of drawing up a national boiler code. We suggest that these two bodies, together with the allied interests, confer for the purpose of drawing up a standard set of refrigerant regulations applicable in all cities and agreeable to all concerned.

Congress and the Public Utilities

Congress has recently passed a public utilities law for the District of Columbia which makes it illegal for any public utility to give discriminatory rates. The Public Utilities Commission of the District has begun an investigation of certain rates given by the Potomac Electric Power Co. which are lower than those in the schedule submitted to the commission by the company.

The users affected declare that the contracts, which were drawn in their favor prior to the passage of the public utilities law, were made in good faith and that Congress had no right to enact any law which would cancel these contracts. The commission maintains that it is not a question if Congress had such a right, but if these contracts contain discriminatory rates.

The opinion to be handed down in this case will be of vital importance to those who operate isolated plants or who are contemplating their discontinuance in favor of the special rates offered by the central stations.

A Perpetual Fake

Four years ago we had something to say about a perpetual-motion scheme, which was then being foisted on the public by the National Mechanical Power Co., of 1548 East Sixty Third Street, Chicago. As then explained, the scheme was the old fallacy of falling weights on the periphery of a wheel, the weights being returned to their starting place at a point on the wheel less distant from the center. The same number of weights is ascending and descending at all times and, due to the longer leverage, those going down are supposed to develop excess energy which may be used for power purposes.

In the company's literature the operation was explained as follows: "Each wheel has two rows of pockets, the inner row, called the short side, and the outer row, the long side. The wheel is made to revolve by falling balls. When a ball has passed up the short side to the top, it rolls out into a rectangular conduit, which is fast on the side of the wheel, and rolls down into the outer row of pockets. After it has reached a point near the bottom of the wheel, it passes through another conduit back into the inner row of pockets and is elevated to the starting point, thereby making the *gravity* greater than the *levity*."

Of course, the device is a fake—and an old one. Unless a motor is concealed in the casing, there is small chance of revolving the wheel, and even then centrifugal force may play an embarrassing part. Notwithstanding these minor difficulties, the same promoters, under the firm name of the International Power Co., have blossomed out suddenly on the west side of the same city. This time, as an extra inducement to buy stock, the company is proposing to build a modern seventeen-story hotel, which will be supplied with power and light by its "fuelless" engine. Also a couple of models will be on exhibition in the lobby, where they may be seen in daily operation by guests of the hotel and prospective customers for stock.

It appears that the company has had the good sense not to give any visual demonstrations of the working of the machine in its present quarters. Blueprints are in evidence and a photograph of the exterior, but the actual models, it is claimed, are in storage as the company wishes to protect the special constructive features it has adopted. In this way it will have a monopoly when the engine is placed on the market and the dividends to the stockholders will be much greater.

It is not known with what success the company has met in its recent operations. It is our hope that the returns have been small. To the public there is not even the diversion of something new. It is high time for the proper authorities to act.

The Wrong Slant

Much repetition of any statement will make it readily believed. Thus, the alleged wastefulness and inefficiency of the steam boiler and engine have been harped on until now they are popularly accepted as just accusations. We occasionally read, in a Sunday newspaper or equally scientific publication, an article worthy of a recent high-school graduate to the effect that from 80 to 95 per cent. of the fuel in power plants is wasted; in fact, is thrown away. The worst of it is that invariably the implication is that the engineering profession is responsible for allowing this condition to exist.

An engineer employed in the mechanical department of a large factory that maintained an elaborate system of cost-keeping was told by a cost clerk that a considerable saving would result from abolishing the power plant. Of course, the engineer answered that abolishing the power plant would also mean abolishing the factory and the position of cost clerk.

The latter had been discoursing on the economy of the other departments and then referred sarcastically to the power plant's ten per cent. (or so) efficiency in the matter of extracting energy from coal. Explaining that the energy in coal was not all available or possible of utilization, and that the oft-repeated charge of wastefulness was unfair to the power plant, was useless, naturally, for any man that can believe the contrary knows too little about mechanical things to be able to understand.

In the scheme of cost keeping at this plant (in others as well) the power plant was regarded as an "expense"; it did not directly produce any of the finished products of the factory and consequently it was an evil, although a necessary one. This feeling is often evidenced by the attitude of those in the manufacturing departments toward the engineer. It does not occur to the cost department to look at it in the light that the engineer manufactures steam for heating and electricity for power and light, from the raw materials, coal and water; hence is to be classed as a producer. This feeling toward the power department sometimes extends to the manager, who often refuses needed improvements in the power plant on the ground that the "expense" must be kept down.

If the power plants of manufacturing establishments are an expense, they will probably continue so until some clerk or bookkeeper succeeds in making an operative "perpetual-motion" machine.

Engineers in Public Service

It has long been customary to regard municipal engineering as the particular province of the civil engineer; only lately has the important role of the mechanical and electrical engineer in such work become recognized. Significant of the new order of things is the fact that the American Society of Mechanical Engineers devoted an all-day session at its annual meeting to public-service affairs.

That the engineer is already an important factor in municipal affairs, and that this influence will extend, is certain, but it is also evident that under present conditions this field is not as attractive as it might be and the engineer is not accorded full credit for his efforts.

As pointed out by Mr. Cooke, in his excellent paper on "Factors in Municipal Engineering," it is difficult to get the high-class man to enter municipal service, or even to act in an advisory capacity, especially when the point at issue is one between the city and some private company. This may be due in part, as he suggested, to the fact that many of the prominent engineers are affiliated with the private concerns either directly or through retainers, but the "red tape" incident to appointments and the restrictions upon the initiative in such positions are probably equally responsible.

Obviously, the remedy is first to make municipal service attractive, so that the best men will be drawn to it, not merely as a monetary consideration, but as a place where the greatest latitude will be afforded to engineering ability. In this way only, will it be possible to build up a personnel of such a standard as to render municipal undertakings independent of outside aid and at the same time able to meet the private interests on equal terms.

Who Gets the Promotion?

The longer you look at the cartoon this week, the more you realize that it is a real problem that is put up to the boss. The situation is a typical one and the experience a very frequent one with those in managerial positions.

The chap who does not get the promotion can think of many reasons why the boss' choice was a poor one. It is only when one is on the outside looking in, as we are in the case of the picture, purely impartially, that we can begin to appreciate how difficult it may be for a conscientious superior to select the one to promote when all have their good points and each deserves advancement.

Take the three in the picture, consider each one by himself and you will agree that you would hate to be in the position of having to decide which should be advanced.

The point of the picture is this: Do not be too quick to criticize the old man's decisions, for perhaps you may not know what circumstances complicated his problem.

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A movement to create a Bureau of Labor Safety in the Department of Labor ought not to scare big business, and elicit squeals from the "Let-us-alone" coterie. Big business ought to be interested in minimizing the death rate in the industrial war. But who objected when unanimous consent was asked for the consideration of such a bill? Smoot!

Correspondence

Detecting Ammonia Leaks

In the Nov. 3 issue, page 656, Robert G. Thurston states that "in testing for leaks in the brine tanks it is best to stop the circulation of brine for a short time and allow the brine to become quite saturated with the ammonia." This is not good practice for this reason: In a brine tank of average size a few pounds of ammonia would be lost into the brine before its presence could be detected by litmus paper or by Nessler's reagent test.

The proper way to test the coils in the brine tanks is to reduce the ammonia pressure in them to about 5 lb. gage; then pump out the brine and test the coils for leakage with a lighted sulphur stick. This is better than to allow the brine to absorb the ammonia until it becomes so saturated that its presence can be detected by litmus paper or by Nessler's reagent.

I have found that smelling the brine is good to discover ammonia leaks, as the brine will give off an ammonia odor long before the litmus paper or Nessler's solution* will indicate its presence.

Further on, Mr. Thurston states that "The greatest sources of ammonia losses are in the compressors, the discharge tanks, the condenser and its valves." I would like Mr. Thurston to explain what he meant when he said "discharge tanks."

The main loss of ammonia in the compressor is caused by leakage past the piston rod through the packing or stuffing-box. This amount should be small in a well regulated plant. Another source of leakage in compressors is the gaskets on the heads, the ammonia so lost being absorbed and carried away by the jacket water. The best and quickest way of detecting such leakage is to operate the compressor without jacket water for a short time, so that the ammonia escapes into the jacket space, and its presence is then readily detected.

One loss in a refrigerating plant, assuming that the system is well looked after and kept reasonably tight, is due to the disintegration or dissociation of ammonia and impurities in the system which cause permanent or noncondensible gases and dead liquor. Deterioration of ammonia is caused by high discharge temperatures and by oil and water in the system. Ammonia gas at high temperatures attacks the iron or steel pipes in the condenser and forms other gases which cannot be liquified at the pressures and temperatures generally carried in the condensers of refrigerating plants.

These permanent gases represent a loss of ammonia, they are a detriment to the economical operation of the plant and they must be removed as soon as possible. Pumping these gases through the refrigerating system causes loss in output and in efficiency. They can be removed by burning them when flowing from the purge valve on the condenser or they may be purged off into a bucket of water. When adopting the latter method it is customary to connect a small pipe to the purge valve and run this pipe into a bucket full of water, submerging the outlet of the pipe several inches below the surface. Then crack the purge valve slightly, and so long as bubbles rise to the surface keep the valve open, but when the bubbles cease to rise and a cracking noise is heard, one may be sure that ammonia gas is escaping from the condenser. Water absorbs ammonia gas with a distinct cracking sound similar to the noise heard when heating cold water with live steam.

The oil and the water in the system will absorb ammonia until they are saturated. The presence of oil is caused by faulty operation, by defective apparatus and by using oil that is not suitable for refrigerating machines.

The main oil trap between the compressors and condensers, which the oil first reaches after leaving the compressors and where it is most readily trapped and drawn off when in the liquid state, should receive the closest attention. It should be equipped with a gage glass and not be allowed to fill to overflowing, so that the oil reaches the condensers, for there it mixes with the ammonia, contaminating it. If the system is not equipped with an ammonia purifier, the oil reaches the expansion coils, and, once there, it is difficult to remove.

Oil for lubricating a compressor cylinder should be free from animal and vegetable fats. These fats are saponified by ammonia, and if they are allowed to enter the system they will soon clog it up. Ordinary mineral oil is also unsuitable, as all such oils contain paraffin, which hardens when chilled. Specially prepared mineral oils should be used, because they have a reasonably high fire test—that is, they remain liquid under high temperatures and will not gasify to any extent (due to the temperature of compression), and thus pass the oil trap as a gas to condense with the ammonia. They have been chilled to zero temperature or lower and the paraffin filtered while solid. An oil so prepared can be used for lubricating ammonia compressors and it will give the least amount of trouble.

Water in the system is, in many respects, more harmful than oil. It gathers in the expansion coils as a mushy frost, and not as a hard lump of ice, as many suppose. In this condition it makes an ideal retainer for any oil that may be in the system.

These two substances, oil and water, in the expansion coils absorb much of the ammonia. The resultant mixture is what is called "dead liquor," which, remaining in the expansion coils, cuts down the efficiency of the coils; also, it reduces the available heat-absorbing surface.

Water enters the system through leaks in the coils or around a leaking compressor cylinder head equipped with a water jacket when any part of the system is pumped down below zero gage pressure for making repairs or for charging in fresh ammonia. It is safer, therefore, to see that the low-pressure gage never registers below zero; in other words, do not pump a vacuum on the system.

When it is necessary to pump down to zero, as in emptying a drum of ammonia, the machine should be lowed down as the back pressure lowers. This should always be done as the needle approaches zero, for with a low back pressure and the machine running fast, a partial vacuum will be formed in the cylinder at the beginning of each stroke. When this happens, it does not take much of a leak around a cylinder head to admit sufficient water to cause trouble.

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*This may be true for old paper or spoiled solution, but not otherwise.—EDITOR.

C. E. Anderson.

Chicago, Ill.

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Diagrams from New Engines

Replying to Mr. Pearce's letter on page 690, Nov. 10, I wish to state that both diagrams on page 427 of the Sept. 22 issue were from the Corliss type, nonreleasing four-valve engines with shaft governors. It was not a case of more or less lead. The difference was due to that in the design of the valve-gear, and it brings out an important point. I have never found that excessive lead alone or combined with excessive compression would raise the efficiency of any engine, but always to the contrary. Quick opening, to me, always meant increased economy, and this is one example. The diagram showing the slow admission was from an engine with little valve travel. No. 2 had a quick valve movement with a large port opening and had less lead than No. 1; No. 2 showed better average economy as nearly as two distinct types of engines could be compared.

The compression was good in both engines. No. 1 has always shown a higher economy on lighter loads. The boiler pressure and indicator springs were nearly the same on the two engines.

C. R. McGahey.

Baltimore, Md.

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Determining Polarity

A simple method for determining the polarity of a circuit, having the added advantage that it does not require any particular preparation, is as follows:

Tear off a piece of blueprint paper (about an inch square will do for 110- and 220-volt circuits) and wet it. Place the two terminals of the circuit about a quarter of an inch apart on a 110-volt circuit and a trifle more on 220 volts. The paper around the negative lead will turn white. A lamp can be placed in series with one of the leads to avoid a short-circuit.

Blueprints are usually available on a job, but I have seen wiremen who had frequent occasion to determine the polarity of circuits, carry strips of blueprints in their tool-kits for this purpose.

P. Justus.

Cleveland, Ohio.

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Remedying a Cut Cylinder

M. E. Griffin's method of machining piston rings for gas engines, in the Oct. 27 issue, recalls a job I once saw on a marine-engine cylinder. This was on the intermediate cylinder of a triple-expansion engine, which was about 30 in. in diameter. Upon taking off the head at the end of a trip, the cylinder was found to be badly scored on one side, the cuts running lengthwise about 10 in. and covering a place about 4 in. wide, half-way down the cylinder; the rest of the cylinder was as smooth as glass. The chief was notified and came down to look at it. After looking it over, he put on his overalls and, jumping into the cylinder, called for a hammer and a flat cold-chisel. With these he proceeded to crosscut the whole spot to the same depth as the lengthwise cuts and when he finished, it was a rough looking cylinder. He climbed out with the remark: "I guess that will fix her," and told us to put the head on.

We made a round trip, and upon opening the cylinder again, I was much surprised to find the spot had nearly disappeared. At the end of a second trip the cylinder was found to be smooth all over and one could not tell where the spot had been.

William N. Wing.

Brooklyn, N. Y.

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Simplifying Reports of Boiler Tests

As one of the members of the Power Test Committee, which has just presented its report at the annual meeting of the American Society of Mechanical Engineers, I am interested in the letter of E. R. Morrison in the issue of Nov. 10 on "Simplifying Reports of Boiler Tests."

He will find on p. 55 of this report what the committee considered the best form for a short report, containing only the principal data and results. It has only 21 items, but gives more information of value to the owner and engineer than does Mr. Morrison's form of 39 items. Moreover, this form is in harmony with all the best literature on the subject of boiler tests that has appeared in the past forty years, including the reports of the 1885 and 1899 committees, the Centennial Exhibition reports of 1876, the American Institute report in 1871, and all the reports on boiler tests that have been made in recent years by officers of the United States Navy. If any "busy brainy man" who is "lost among the confusion of unnecessary technical phrases" does not understand this form, all he needs to do is to get his engineer to explain it to him. He would not understand "standard fuel" and "standard evaporation" any more than he would understand "B.t.u." and "from and at 212 deg."

William Kent.

Montclair, N. J.

The writer agrees with the views of Mr. Morrison, as expressed on p. 667 of the Nov. 10 issue, that many boiler-test reports could be shortened to advantage and that the chief things which interest the business man are the capacity and economy obtainable. If he is sufficiently interested to pay for obtaining this information, he will probably also wish to know how it compares with the best practice and the reasons, should it fall short.

Mr. Morrison introduces the skill of the fireman as an item, but this is presumably based on the judgment of the engineer conducting the test, and is likely to be a variable factor. It is better to give a complete heat balance as this involves comparatively little extra work and gives exact figures upon which to place the responsibility for the various losses. In fact, the heat balance has been made too much of a mystery in books and it no longer requires an ultimate analysis of the fuel, for if the region from which the latter comes is known, a similar coal can be found in the reports of the United States Bureau of Mines and the ultimate analysis of this can be used in accordance with the method described by Prof. E. E. Sommermeier in his book on "Coal," p. 54.

The writer prefers the following form of heat balance:

1. Heat utilized in evaporation;
2. Loss due to latent heat of water resulting from hydrogen in coal;
3. Loss in products of combustion;
4. Loss due to excess air;
5. Loss due to unburned carbon monoxide;
6. Loss due to unburned carbon in ashpit;
7. Loss due to radiation and that unaccounted for, etc.

The methods of calculating these are fully given by Prof. Sommermeier and need not be repeated here, but the writer has found an even simpler method which gives on tests with coals from the Eastern fields, results accurate to 0.1 per cent. on the heat balance. This is based on the fact that while the heat values of carbon and hydrogen per pound of each are widely different, the heat developed per pound or per cubic foot of oxygen or air used to burn them is not very different. Hydrogen develops 62,500 B.t.u. per lb., and requires 8 lb. of oxygen for combustion, while carbon develops 14,650 B.t.u. per lb. and requires only 2⅔ lb. of oxygen. This, taken with the rather small and uniform percentage of hydrogen available for combustion, results in the weights of the products of combustion being directly proportional to the heat developed. From the heat balances of a large number of tests worked up in the regular manner the writer finds that item 3, the loss in the products of combustion, will be approximately two per cent. of the heat of the fuel for each hundred degrees Fahrenheit, by which the temperature of the flue gases leaving the boiler exceeds that of the air entering the ashpit. Or, putting it in the form of a formula:

$$\textit{loss in products of combustion (in per cent.)} = 2 \times \frac{T_F - T_A}{100}$$

where

T_F = Temperature of gases leaving boiler;
F_A = Temperature of gases entering ashpit;

The excess air may be calculated from the gas analysis by the formula:

$$\textit{percentage of excess air} = \frac{O}{0.265\,N - O}$$

and

$$\textit{per cent. loss in excess air} = 1.70 \times \textit{per cent. excess air} \times \frac{T_F - T_A}{100}$$

In a similar way it has been found that

$$\textit{loss in unburned carbon monoxide (in per cent.)} = 60 \times \frac{CO}{CO_2 + CO}$$

Items 1, 2, 6 and 7 are calculated in the usual manner, but it will be found that the above three items correspond to the greater amount of work in figuring the heat balance and are the most important in judging of the performance of the boiler.

If possible, gas samples should occasionally be taken at the top of the first pass in a vertically baffled water-tube boiler, or at a point where air leakage through the setting has not had an opportunity to dilute the gases of combustion simultaneously with those at the uptake. The latter should be taken at the point where the temperature of the escaping flue gases is taken. This is especially important in obtaining an accurate heat balance, for, if the products of combustion become diluted by air leakage after passing the pyrometer and before reaching the sampling tube, the heat balance will show too high a loss up the stack and *vice versa*. If gas samples taken close to the fire along the path of the gases show a satisfactory and considerably higher CO_2 than those at the flue, this will indicate that the fireman is doing his work properly, but that the boiler setting is leaking badly. A tight setting should not allow over twenty-five to thirty per cent. excess air to leak in between the end of the first pass and the flue, and if more than this is found the cracks should be searched out with a candle and plugged. Old magnesia pipe covering made into a paste with water is satisfactory for this purpose.

The maximum permissible loss in the products of combustion varies somewhat with the equipment and conditions of operation, but it should seldom exceed nine per cent. unless the boilers are being forced to an unreasonable extent. A greater loss than this indicates dirty boilers, leaky baffles, or the carrying of such a thick fire that at times the gases burn all the way through the boiler, which can be determined by physical inspection.

The loss in excess air and that in unburned gas are somewhat dependent on each other, for as the latter is diminished, the former is increased. In general, it pays to keep the loss in unburned gases as low as possible. The point of best economy even with perfect firing will depend on the furnace volume and the rate of driving. With boilers set high above the grates it is possible to attain 15 per cent. CO_2 at 200 per cent. rating, giving not over 3 per cent. loss in excess air with a negligible quantity of carbon monoxide; in those set low a fireman usually has difficulty in averaging 11 or 12 per cent. CO_2 without making much carbon monoxide, even at low rates.

In general, a fireman's work can be considered satisfactory if the gas analyses show good CO_2 with an occasional 0.2 or 0.3 per cent. CO. Losses in unburned CO of over 1 per cent. are excessive and permissible only if the draft is limited and extreme capacity is required. Even in such cases steps should be taken to remedy the situation, for when a fire is being carried at the point where a slight amount of carbon monoxide is formed, it requires only a slight change in conditions to increase this sufficiently to cause a 10 to 20 per cent. loss.

With proper grates, losses due to carbon in the ashpit are largely under the control of the fireman and result from carelessness in cleaning fires, shaking the grates too much or from too much barring and working of the fires. Except when the grate is too coarse and entirely unsuited to the fuel or the coal clinkers badly, the refuse should not contain over 30 per cent. combustible with low-ash coals and less with those of higher ash content; hence, item 6 should not exceed 3 per cent. In endeavoring to lower this figure more is likely to be lost in excess air passing through holes in the fire than could be saved.

The last item (7) is obtained by difference and forms a valuable check on the test, especially in comparison with other tests, as any errors in the other items affect it directly. The absolute value of the radiation part seems rather uncertain, but for the whole item the values seem to range from 12 or 15 per cent. for small boilers set singly and operated at rather low rates, to 7 or 8 per cent. for fair-sized units at average rates, down to 2 or 3 per cent. for very large boilers steaming at high rates, such as those at the Delray station of the Detroit Edison Co.

With the usual methods of gas analysis, losses due to unconsumed hydrogen, hydrocarbons, etc., also fall in this item and, if conditions are very bad, may increase it considerably. The writer's experience on a series of tests where conditions were such that there was a marked evolution of these gases, and the flue gases were carefully analyzed for them, was that these losses about equaled those due to unburned carbon monoxide; applying such a correction to other series of tests brought the radiation items into closer agreement.

As a rul item 2 (the loss due to latent heat) will be between 2.5 and 3 per cent., depending on the moisture content of the coal. It is an item entirely independent of the plant or operating force as it depends only on the quality of the fuel.

Summing up all these items, the writer would say from an extended experience in boiler tests that the following tabulation represents about what can be expected in the way of the "best," "good" and "poor" results under average power-plant conditions. Exceptional conditions, of course, may enable one to do somewhat better in some of the items:

Item	Title	Best	Good	Poor	
1	Heat utilized in evaporation.. ...	78.5	72.3	59.0	59.0
2	Loss due to latent heat ..	2.5	2.7	3.0	3.0
3	Loss in products of combustion.	8.0	9.0	12.5	11.0
4	Loss in excess air...	3.0	5.0	3.5	14.0
5	Loss due to unburned carbon monoxide	0.0	0.5	5.0	0.0
6	Loss due to unburned carbon in ashpit	2.0	3.0	5.0	5.0
7	Loss due to radiation, etc	6.0	7.5	12.0	8.0

Two typical heat balances are shown in the "poor" column, the first where the losses are largely due to carrying too thick a fire with a waste of unburned gases; the second due to holes in the fire with high excess air and perhaps leaky baffles. These are by no means the worst the writer has encountered, but they are unfortunately too near the average of what occurs in many boiler plants.

H. D. Fisher.

Newton Highlands, Mass.

Stop for Gasoline Engine

The sketch shows a device employed to stop automatically a 12-hp. gasoline pumping engine in a railroad water station. The tank is about 6000 ft. from the pump house, and bolted to the roof of the former is a box 18 in. long and 4 in. square. A slot is cut lengthwise in it to allow a bolt to slide up and down, the end of the bolt being attached to a wooden float in the box. As the water level falls in the tank the bolt acts as a stop and allows the float to fall only a short distance. A copper point and one of the wires to the engine stop is fastened to the end of the float stem and a notched piece of copper, connected with the other wire, is attached to the roof of the tank directly over the float stem.

At the pumping station there is a small upright post carrying a hinged wooden lever. The latter is ordinarily supported in a horizontal position by the free end resting on a small projection of a second upright stick hinged at the lower end and carrying a piece of soft steel at the upper. An electro-magnet, placed near the soft steel, is connected in the tank circuit. There is also a switch in the line just above the horizontal lever. The latter carries a weight near the center and this switch is attached to the weight by a cord, as is also the switch in the ignition circuit.

When the water rises in the tank to the desired level and the copper contacts close the tank circuit, the electro-magnet is energized and attracts the piece of steel on the upright stick, thus releasing the weighted lever, which drops and pulls out both the switch on the tank circuit and the one on the engine circuit.

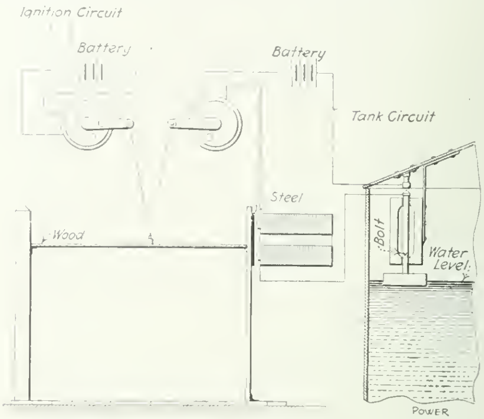

Diagram of Tripping Device and Circuits

The current for the tank circuit is supplied by six dry cells and as the circuit is closed only long enough to cause the electro-magnet to act, the cells will last a long time. Aside from the wire used, the only outlay was 80 cents for the magnet, the rest of the material being picked up around the plant.

S. A. Standley.

Fort Wayne, Ind.

Attention of Firemen

On reading Mr. Dixon's comments in the Oct. 27 issue, under the heading "Poor Firemen," and which criticized the editorial, "Attention of Firemen," in the Sept. 15 issue, I referred to the latter issue and again read the editorial. I agree with Mr. Dixon. He quotes the case of a fireman traveling twenty-five miles three times a week to attend the evening sessions of a technical school. As Mr. Dixon says, it may be an extreme case, but it shows the spirit in this state.

Many industrial schools, which teach many kinds of trades and engineering are scattered over Massachusetts. There are evening sessions for day workers and special morning sessions for night workers. At the industrial school in this city we have four evening classes of eighteen pupils each, a morning class of seventeen, an evening class on the same lines at the local textile school with twelve pupils, and twenty pupils go once a week to a private school fourteen miles away; this makes a total of 121 men engaged in operating steam plants. This number includes men from coal passers to chief engineers, a large percentage being firemen.

It is a creditable showing for a city of 100,000.

John Powers.

New Bedford, Mass.

Emery around a Dynamo

Some time ago a correspondent in Power stated that emery is a good conductor of electricity and for that reason should not be used on a commutator. This impression, which is held also by many power-station men, evidently is the result of expressions by certain well known authors, which would lead one to believe that emery is a conductor of electricity. I have always used emery cloth on commutators and have never had any trouble traceable to that source. Furthermore, I have tested emery and emery cloth repeatedly and have invariably been unable to find any that was a conductor of electricity.

Recently, to settle an argument with one of my engineers, I inserted both terminals of a magneto in a five-pound can of emery, but I could not ring through. We then placed some of the emery on a piece of paper and applied the terminals of the magneto, but the bell was silent. Finally, we brought the terminals closer and closer together and, to the engineer's astonishment, the bell would not ring until they had been brought into contact with one another. We repeated the experiment with emery cloth and got the same results.

I was taught early that copper dust would cause trouble and soon found out that, if any grinding was to be done around a commutator, it was much better to wait until the machine was dead. Furthermore, I found it well to immerse the emery cloth or sandpaper in thin, clean engine oil and then wipe off all of the oil with a clean rag. Of course, the emery cloth or sandpaper did not last as long, but I was quite sure that by employing this means no copper dust was liberated to get into the windings or back of the commutator lugs under the windings, such as to short-circuit the adjoining bars. Unquestionably, dust of any kind is a bad thing around electrical machinery, and for that reason, ordinarily, it is bad practice to grind commutators with emery cloth. However, an operating engineer is bound to run into a variety of circumstances, and will find many times that oiled emery cloth is convenient for smoothing a balky commutator.

At present, I have a motor-driven exciter, upon which I have used emery for some time. It is applied with a block which just fits the periphery of the commutator. The machine is now running much better than when first installed; moreover, the commutator surface has a hard, mahogany appearance and requires practically no attention. My idea is to get a hard, glossy surface and then leave it entirely alone, not putting anything on the commutator. About all that is ever required is to remove the brushes one by one and wipe off the accumulated dust.

The worst feature of emery is that the grit becomes embedded in the copper and brushes, with a tendency to produce a continual cutting. However, if the brushes are removed before grinding and the commutator is carefully wiped off with a clean cloth saturated with new engine oil, no trouble should be had from that source. I would advocate the use of emery as follows:

1. Commutators worn out of round or cut should be turned off without delay, if conditions permit, and then ground to a hard glaze with oiled emery cloth. Use oiled sandpaper for the final finish and then turn the sandpaper over so as to buff the surface of the commutator. Never use a file on a commutator to any great extent—just enough to knock off the burrs of copper.

2. When using oiled emery cloth: Remove the brushes; use a wood block which fits the commutator snugly; pay particular attention to getting the proper speed for grinding; use high speed at the finish; do not forget to examine the mica between the commutator bars for bridges of copper; if the mica has been undercut, go over all the slots carefully and remove all dust.

3. Brushes: A brush which is good for one machine may be unfit for another; special brushes must receive careful adjustment of the spring tension; I have used a certain make of brush which increased the capacity of direct-current motors and generators more than 25 per cent. above the former "arcing-over" point.

4. Slotting of commutators: Not always a success; causes destructive chattering of brushes in many cases; destructive to high-grade, soft-composition brushes since it wears them away too fast; shallow undercutting of mica has given best results in most cases.

Waldo Weaver.

Emporia, Kan.

⁂

Better Draft Regulation

In a certain plant there are two water-tube boilers, rated at 275 and 300 hp., respectively, which are connected to the same steam main. The smaller has a short straight pass to the stack and the larger is about 20 ft. from its stack. Each has one automatic damper and both are operated by the same damper regulator. The smaller unit had better draft and carried more than its share of the load. To correct this condition, extra dampers were so placed in both stacks that the fireman could control them and equalize the load. Another way would be to install a quick-acting damper regulator on the larger boiler which would act before the one on the smaller boiler, but the method used was the cheapest.

It is good practice when one damper is provided, and that controlled automatically, to install such an auxiliary damper. It should be within easy reach of the fireman, where it is more likely to be used. Otherwise, he may not close the damper when cleaning the fires, and then large quantities of cold air will be admitted through the open doors, causing serious strains and damage to the boiler and setting.

W. F. Rockwell.

Boston, Mass.

⁂

Repair Jobs with Iron Cement

As letters frequently appear on the use of various iron cements, my experience, while in charge of a plant in the West Indies, may help somebody.

The plant was condensing and had a rather antiquated rotative dry-vacuum pump for a spare unit. One day the air piston rod broke at the crosshead, the piston being driven back against the cylinder head. The force of the blow was not sufficient to break the head on the air-cylinder side, but it cracked the water jackets of the head on the outside. The cracks were radial from the center of the head and caused the cooling water to leak considerably.

We scraped off all the paint along the cracks to get the metal clean. Then we piped the water inlet of the head to the vacuum line from another pump and covered the other outlets with pieces of heavy sheet packing. Air was drawn in through the cracks in the head, which were covered with a fairly thin mixture of smooth-on cement; this was quickly drawn into the breaks and the cracks were sealed after allowing the cement to harden. The pump has been operated regularly for three years and the water jacket does not leak.

By the same method, I was able to stop a leak in an 8-in. steam line, carrying 125 lb. steam pressure. This leak was around the threads at a flange in a section of the main which could be shut off from the rest of the system, but connected with a 238-hp. boiler.

One day, when the boiler was cold, I filled it with water and then, with all the valves closed, including the sectioning valve on the steam main, the pressure was taken from the leaking part. All the metal around the leak was cleaned as thoroughly as possible and the main valve opened. Next, the blowoff valve was opened wide, causing air to enter through the small leak. This air leakage was then stopped by a thin smooth-on paste as in the other case. When the steam was afterward turned into this section of the header there was no sign of a leak. Although this repair job was only meant to be temporary, it is still steam-tight after a year's service.

F. E. Meredith.

Boston, Mass.

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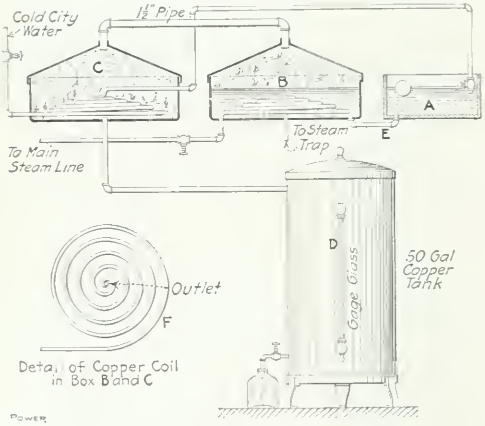
Water-Distilling Apparatus

The sketch illustrates an apparatus for distilling city water for drinking purposes. The part *A* is an ordinary 8x18x10-in. watertight wooden box, containing a copper-ball float and valve for regulating the height of water in the box *B*, so as to cover the steam coil about 1 in.

The water from the box *A* flows by gravity to the box or evaporator *B*, through the connecting pipe *E*, connected from the bottom of *A* to *B*, thus insuring the steam coil in *B* being fully covered with water when in use.



Outfit for Evaporating Drinking Water

The evaporator *B* and the condenser *C* are round copper pans about 28 in. diameter by 8 in. deep, tinned on the inside and lagged on the outside with 1-in. magnesia asbestos pipe covering. In the bottom of the evaporator and condenser are two round, flat coils two pipes high, constructed of ¾-in. copper pipe well tinned on the outside. The top of the evaporator has a snug-fitting, funnel-shaped copper cover, with a 1½-in. outlet at the top, which connects with a similar arrangement on the condenser *C* by a 1½-in. pipe.

One end of the coil in *B* is connected to the main steam line with a globe valve between the coil and header, while the other end is connected to a steam trap. As the water boils in the evaporator *B*, it passes up and out through the 1½-in. pipe connection at the top and into *C*, where it is condensed when it comes in contact with the cold-water coil in the bottom.

The condensate then passes out by gravity through the 1-in. line in the bottom of *C* into the copper tank *D*, which is an ordinary 50-gal. tank, such as is used by lunch counters and restaurants to hold ice water.

The cold water in the coil in the condenser is not wasted. It is piped over to the box *A*, thereby saving a few heat units, as the water coming from the condenser coil is fairly warm: this materially helps the evaporator. From the tank *D* the distilled water is drawn off into 5-gal. bottles and distributed throughout the building to the water coolers as it is needed. By this home-made device we have saved much money on drinking water, as it was cheaper to distill water than to pay 10c. per gal. for it from some so called mineral-water company.

C. E. Anderson.

Chicago, Ill.

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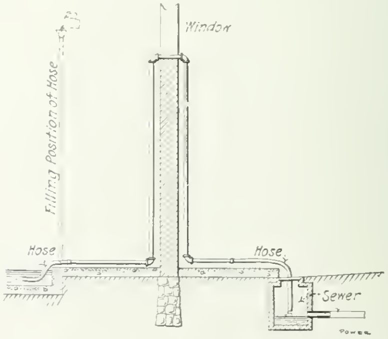
Starting a Siphon

The practice of filling a siphon and then opening the outlet to start it is well known. While effective under proper conditions, it is not always practical to use this method. The manner of starting here described and illustrated is efficient under most conditions and it permits the pipe line for the siphon to be arranged to best advantage before the siphon action is started.

Place the hose or pipe line in position, with its outlet end a few feet or so below the water level to be acted upon. Raise the inlet end above the highest level of the head to be overcome. The inlet is filled until the water begins to flow from the outlet. As soon as the flow occurs, the inlet end is closed and lowered into the water and reopened; this last operation will take but little time and it will not break the flow of the siphon.



Siphon Filled from Inlet End

While a hose is most desirable, it is not essential in all cases. Pipe may be used, it being only necessary to have it arranged to swing easily from a vertical to a horizontal position for the transfer of the inlet end from the filling to the drawing position.

A. P. Connor.

Washington, D. C.

Inquiries of General Interest

Value of Proximate vs. Ultimate Analyses of Fuel—Why is not the proximate analysis of fuel as reliable as the ultimate analysis for determining the heat value of a fuel?

T. W.

The proximate analysis gives the proportions of fixed carbon, volatile combustible matter, moisture and ash, and while it affords information as to the general characteristics of a fuel and relative value, the heat value cannot be directly computed from it as in an ultimate analysis because the volatile content varies widely in composition and heat value.

Distinguishing Iron from Steel—How can I distinguish wrought iron from steel by its appearance and without heating the material?

G. K.

The structure of steel will show an evener and finer grain than iron. By drawfiling the side of a rolled bar or plate of the material and applying an acid, iron will show a drawn-out, fibrous structure, while steel will exhibit a structure practically devoid of fibrous appearance.

Heating Surface per Lineal Foot of Pipe—What amount of heating surface is allowable per lineal foot of iron pipe of sizes used for steam heating coils?

B. J. W.

The sizes of iron pipes used for steam heating coils are usually from ¾ to 2 in. diameter, though 1 in. and 1¼ in. are the sizes most commonly employed.

1 lin.ft. of ¾-in. pipe has 0.2748 sq.ft. of heating surface.
1 lin.ft. of 1-in. pipe has 0.3442 sq.ft. of heating surface.
1 lin.ft. of 1¼-in. pipe has 0.4345 sq.ft. of heating surface.
1 lin.ft. of 1½-in. pipe has 0.4975 sq.ft. of heating surface.
1 lin.ft. of 2-in. pipe has 0.6218 sq.ft. of heating surface.

Taking Out Bag of Boiler Shell—When a bag has formed on the shell of a horizontal return-tubular boiler what objection, if any, would there be to heating the bagged part with a powerful torch and forcing the bag back into place by pressure or pounding from the outside?

A. B.

In the formation of a bag the sheet becomes stretched and reduced in thickness, and to restore the shell to its original form the bag cannot be removed without leaving a buckled surface except by an upsetting process of forcing the material back to its original form and thickness, employing a "hold back" or anvil on the inside. Although heating and straightening the sheet may be skillfully performed, the process is likely to impair the homogeneity and strength of the material and is therefore objectionable.

Delivery by Triplex Plunger Pump—Allowing 5 per cent. slippage, how many gallons per revolution of the crankshaft will be pumped by a geared triplex plunger pump having three plungers each 3 in. diameter and 4 in. stroke.

J. C. W.

The cross-sectional area of each plunger would be

$$3 \times 3 \times 0.7854 = 7.0686 \text{ sq.in.}$$

hence the displacement by each plunger would be

$$7.0686 \times 4 = 28.2744 \text{ cu.in. per stroke}$$

and as a gallon is equal to 231 cu.in., then for three plungers the displacement would be

$$\frac{28.2744 \times 3}{231} = 0.3672 \text{ gal. per revolution}$$

and allowing 5 per cent. slippage, the delivery would be

$$0.3672 \times (100 - 5) = 0.3488$$

or practically 0.35 gal. per revolution.

Variation of Pressure Required for Air Lift—In pumping from a well with an air lift, why is it necessary for the air supply to be about six pounds greater pressure in starting the lift than for keeping it in operation?

J. D. W.

The air pressure must be sufficient to overcome the hydrostatic pressure in the well at the point where the air first comes in contact with the water. During pumping, the flow to the well cannot sustain the same hydrostatic pressure as in the beginning of pumping and consequently a higher air pressure is required in starting the air lift than for keeping it in operation. This reduction of hydrostatic pressure is sometimes referred to as "drop" of the well and a reduction of 6-lb. pressure would be equivalent to a drop or a reduction of air-pipe submergence amounting to about.

$$6 \text{ ft.} \div 0.434 = 13.8 \text{ ft.}$$

Nitrogen Detrimental to Efficiency—In combustion of fuel, what part is taken by nitrogen contained in the air supply and contained in the fuel?

D. A.

The nitrogen contained in the air supply performs no useful office in combustion and passes through the furnace without change. It dilutes the air, absorbs the heat and reduces the temperature of combustion, and as each pound of air at atmospheric pressure contains about 0.7685 lb. of nitrogen it is the chief source of heat loss in furnaces. Nitrogen contained in the fuel, either free or in combination with other substances, is inert in the process of combustion, and as it absorbs heat without producing any benefit, its presence is detrimental. Since the specific heat of nitrogen is 0.2438, each pound of nitrogen, whether contained in the air supply or the fuel used, causes a loss of 0.2438 B.t.u. for each degree F. difference between the temperature of the chimney gases and the temperature of the air supply.

Relative Stress in Horizontal and Girth Seams—How is it explained that in a cylindrical shell the stress per unit of length of a girth seam is one-half as much as for a unit of length of a horizontal seam?

D. J.

The total stress resisted by a girth seam is equal to the pressure per square inch multiplied by the cross-sectional area of the shell in square inches, i.e.,

$$\text{pressure} \times \text{diameter} \times \text{diameter} \times 0.7854,$$

and as the length of the girth seam is diameter × 3.1416, then the stress per unit of length of a girth seam is

$$\frac{\text{pressure} \times \text{diameter} \times \text{diameter} \times 0.7854}{\text{diameter} \times 3.1416} = \frac{\text{pressure} \times \text{diameter}}{4} \qquad (a$$

The total stress resisted by a unit of length of a longitudinal seam is,

$$\text{one-half of (pressure} \times \text{diameter} \times 1) = \frac{\text{pressure} \times \text{diameter}}{2} \qquad (b)$$

Comparing the values (a) and (b) it is seen that the stress per unit of length of a girth seam is one-half that for a unit of length of a horizontal seam.

Heating Surface of Return-Tubular Boiler—What is the method of calculating the heating surface of a return-tubular boiler 66 in. in diameter by 16 ft. long, containing 98 tubes, 3 in. diameter by 16 ft. long?

E. T.

The usual rule is to consider as heating surface all of the surfaces exposed to the flame or heated gas on one side and water on the other. This for return-tubular boilers with average brick settings will be approximately equivalent to (a) half the area of shell; plus (b) the area of the tubes; plus (c) the area of one head minus twice the total cross-sectional area of the tubes. Taking all dimensions in inches, one-half of the area of the shell would be

$$\frac{66 \text{ in.} \times 3.1416 \times (16 \times 12)}{2} = 19{,}905.1 \text{ sq.in.} \qquad (a)$$

The internal diameter of a standard 3-in. boiler tube being 2.782 in., the internal area of the tubes would be

$$2.782 \times 3.1416 \times (16 \times 12) \times 98 = 164{,}450.5 \text{ sq.in.} \qquad (b)$$

The gross area of one head would be

$$66 \times 66 \times 0.7854 = 3421.2 \text{ sq.in.}$$

and as the total cross-sectional area of the tubes would be

$$(2.782 \times 2.782 \times 0.7854) \times 98 = 595.7 \text{ sq.in.}$$

the heating surface of the heads would be taken as equivalent to

$$3421.2 - (595.7 \times 2) = 2229.8 \text{ sq.in.} \qquad (c)$$

Adding results (a), (b) and (c) gives

$$19{,}905.1 + 164{,}450.5 + 2229.8 = 186{,}585.4 \text{ sq.in.}$$

or

$$\frac{186{,}585.4}{144} = 1295.7 \text{ sq.ft. of heating surface.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design—IX

Hot-Blast Heating in Machine Shop and Foundry

Although direct radiation is used to some extent in buildings of this kind, it is not well adapted to those of large size and of modern construction. It provides no means of ventilation, except by air leakage, and when used in buildings having a large glass exposure, such a quantity of radiating surface is required that certain parts are apt to become overheated. This is especially true in those having a considerable height with galleries and monitor roof as in Figs. 2 and 6. In cases of this kind the heat rises rapidly to the upper part of the building overheating it and increasing the transmission through the roof, while the space near the floor remains too cold for comfort, except near the coils, where it is likely to be excessively hot. In some departments, however, direct coils may be used to advantage, either alone or in combination with a ventilating fan. In most large manufacturing buildings, at the present time, the fan system is employed, being especially adapted to this class of work. With this arrangement, the warm air may be so distributed as to heat the space evenly, and at the same time provide an abundance of fresh air for ventilation. When the supply of exhaust steam is limited, the heating plant is usually designed to recirculate the air within the building in the coldest weather, admitting more and more fresh air as the outside temperature rises.

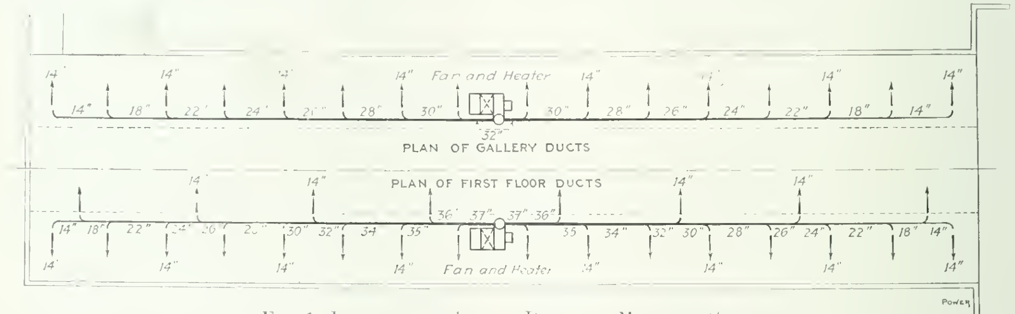


Fig. 1. Layout and Size of Ducts in Machine Shop

The location of the apparatus and the method of distributing the air will depend somewhat upon the type and construction of the building. A plan commonly adopted in machine shops of brick and steel construction is to place the fan and heater overhead and carry distributing ducts of galvanized iron through the roof trusses. From here, branches are brought down on posts and the air discharged directly downward or at an angle so as to throw the greater part toward the outer walls. If the width of the bays is less than 20 ft., this plan works well with the discharge outlets about 5 or 6 ft. from the floor. If the air must be thrown a greater distance the outlets should be placed at a higher elevation and the angle from the vertical increased. By this means it is possible to maintain a stratum of warm air near the floor where it is most needed. When the central part of the building is used for erecting or other purposes, where a certain number of workmen are employed, a smaller amount of air should be discharged in this direction.

If the plant is designed for recirculation of air for the total heating in the coldest weather, return ducts should be provided with openings near the floor along the outer wall; otherwise the circulation will be local and the more distant parts of the building will not be reached. It is not generally necessary to provide any mechanical means for the discharge ventilation, as this may be taken care of by leakage, and through the monitor windows in mild weather.

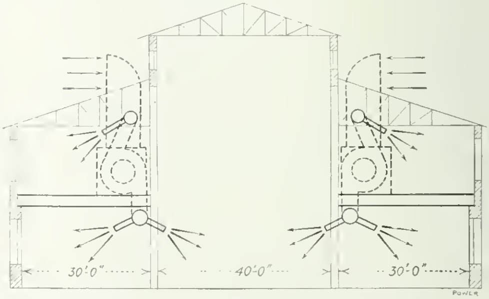


Fig. 2. Sectional Elevation, Showing Fans on Galleries

In the case of foundries the conditions are somewhat different, as the air at times is filled with steam and heavy gases, and it is advisable to provide an exhaust fan. Here, ventilation by monitor windows only serves to make conditions worse, as the entering cold air causes the steam to condense on the walls and overhead construction and drip to the floor. In general, the air in foundry work should be delivered at an angle downward toward the outer walls and removed through vents near the floor along the central aisle or bay.

Having considered the subject briefly, let us apply it to the case in hand and decide upon the best arrangement to employ. All computations relating to the fans and heaters have been worked out in a previous article, so that only the location of the fans, and the method of running the distributing ducts, need be considered at the present time.

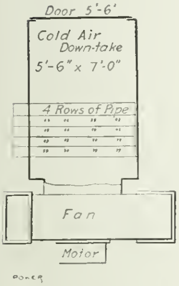


FIG. 3. PLAN OF FAN AND HEATER

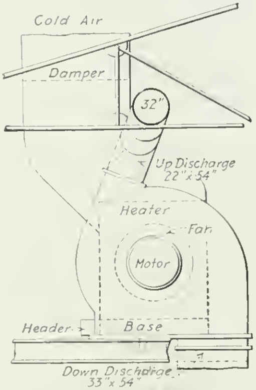


FIG. 4. ELEVATION OF FAN, GIVING SIZE OF OUTLETS

MACHINE SHOP

The general arrangement of the heating apparatus for this building is shown in plan in Fig. 1 and in sectional elevation in Fig. 2. The units are placed on the gallery level, one on either side, about midway. Each fan has two discharge outlets one up and the other down, connecting with two sets of horizontal distributing ducts or mains running the entire length of the building and located as shown in Fig. 2. As the width of the outer bays is more than 20 ft., it is necessary to deliver the air at a fairly high elevation in order to reach the outer wall. The arrangement upon the first and second floors is practically the same except in case of the former a certain amount of air is blown into the central part of the building. The relative supply of air to different parts of the building is as follows:

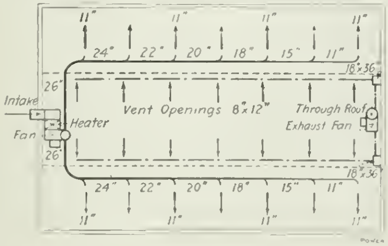


FIG. 5. PLAN OF FOUNDRY

Outer bays, first floor, two-fifths; central bay, one-fifth; galleries, two-fifths. The outlets are approximately 25 ft. apart in the galleries and outer bays, and 50 ft. apart for the central portion.

The fresh air is supplied through special flues extending through the roof and arranged to take in the air on the side away from the monitor windows. These inlets should be provided with louvers and strong wire netting to keep out storm, leaves, birds, etc. Dampers should be placed in the downtakes above the heaters for closing when the fans are not running. A plan and elevation of the fan and heater arrangement are shown in Figs. 3 and 4 respectively. As there is an abundance of exhaust steam available in the present case, the air will always be taken from outside, except perhaps at special times when it is desired to heat the building quickly in the morning or in extremely cold weather when the temperature drops considerably below zero.

Under these conditions it has not seemed necessary to provide return ducts, but large doors have been placed in the heater casings so that the air can be recirculated if desired. This arrangement will be satisfactory for occasional use although the circulation will not be so complete as with a return duct.

There are two common ways of determining the size of the distributing ducts. One is to allow a velocity of 2000 to 3000 ft. per min. in the trunk lines, reducing to 1200 or 1800 ft. in the branches, according to the length of run. When the air is discharged from a considerable height, as in Fig. 2, the velocity should be fairly high so that the air will reach the outer walls. Another method, and the one employed in the present case, is to make the area of the main duct the same as the discharge outlet of the fan, and proportion the branches according to the factors given in Table 1.

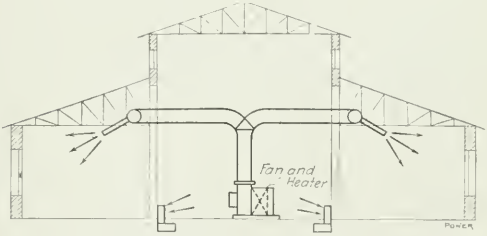


FIG. 6. TRANSVERSE SECTION THROUGH FOUNDRY

In the last lesson the outlet area of an 8-ft. fan was given as 18.6 sq.ft. while a catalog of standard make gives it as 20.2 sq.ft. For present purposes we will take it as 20. Referring to Fig. 1, there are 24 outlets from the lower air duct, so that the areas of the bottom and top outlets from the fan casing must be in the ratio of 24 to 16 or 3 to 2. If the total area is 20 sq.ft., then the two outlets must have areas of 12 sq.ft. and 8 sq.ft., respectively. The width of fan casing is given in the catalog referred to as 4.5 ft., so the outlets may both be made this width, with the other dimensions

$$12 \div 4.5 = 2.7 \ ft.$$
$$8 \div 4.5 = 1.8 \ ft.$$

which expressed in inches, gives dimensions of 33 × 54 in. and 22 × 54 in., respectively.

Next, let us determine the size of the ducts by the use of Table 1.

TABLE 1—DUCT DIAMETERS AND CORRESPONDING FACTORS*

Dia. of Pipe, In.	Factor	Dia. of Pipe, In.	Factor
6	88	22	2,290
7	130	24	2,845
8	180	26	3,470
9	244	28	4,175
10	316	30	4,960
12	500	36	7,800
14	733	42	11,400
16	1,032	48	16,000
18	1,385	54	21,400
20	1,800	60	28,000

*Abridged from the "Metal Worker."

Taking the upper duct first, the fan has an outlet of 8 sq.ft., which is nearly the area of a 40-in. round pipe. The nearest size to this in the table is 42 in., which has a factor of 11,400. This duct has 16 outlets in its entire length, so

$$11,400 \div 16 = 712$$

is the factor to look for in the table in determining the size of outlets and we find it corresponds to a 14-in. pipe.

In finding the size of the two main branches as they separate above the fan, a factor of 5700 is obtained by dividing 11,400 by 2, which comes between a 30-in. and 36-in. pipe, but may be safely estimated as 32 in. Proceeding in like manner the dimensions for the entire duct were obtained and marked on the plan in Fig. 1.

The lower outlet has an area of 12 sq.ft., which corresponds nearly to a 48-in. pipe, or a factor of 16,000 Dividing this by 2, and proceeding as above the factor is 8000, and this corresponds to a 37-in. pipe as nearly as can be estimated. Using 14-in. outlets, the same as for the upper duct, the required dimensions of the main are found to be as marked in the drawing, Fig. 1. Each outlet should be flared to about 20 in. in diameter at the mouth and provided with an adjustable damper operated by chains from the floor.

FOUNDRY

The general arrangement of the heating and ventilating apparatus for the foundry is shown in Figs. 5 and 6. The fan and heater are located on the floor at one end of the building and the fresh air drawn in through a flue carried up about 10 ft. on the outside of the building. The method of air distribution is practically the same as for the machine shop, but in this case an exhaust fan is provided. The vent ducts are carried beneath the floor and the outlet openings are placed against the posts on either side of the central aisle or bay. The vent fan is suspended from the roof trusses at the other end of the building, above the main doors, and is thus well out of the way. The underground ducts are of cement and all overhead piping of galvanized iron.

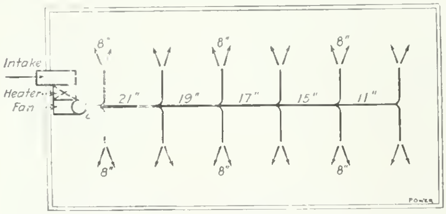


FIG. 7. HOT-BLAST SYSTEM IN FORGE SHOP

Pipe sizes for the overhead distribution were computed in the same manner as for the machine shop, and are indicated on the drawing. Connections between the vent registers and the exhaust fan are proportioned on a basis of 1200 ft. per min. velocity.

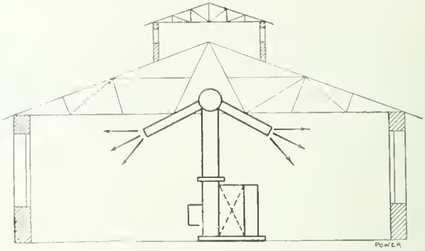


FIG. 8. FORGE SHOP IN SECTION

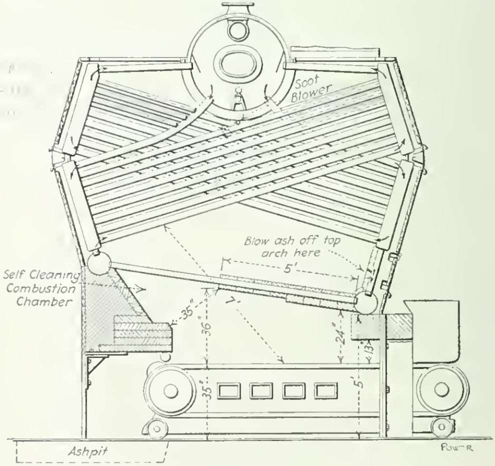
All inlets and outlets are provided with regulating dampers for equalizing the flow of air.

FORGE SHOP

The arrangement for the forge shop is practically the same as for the foundry, except that the exhaust fan is omitted. By this method the monitor windows are depended upon for discharge ventilation. Blowing the air against the outer walls tends to prevent the smoke from collecting under the eaves and drives it into the monitor. Sometimes an exhaust is provided for winter use if too much heat is carried off through the monitor windows.

New Setting for Worthington Boiler

The furnace setting shown in the accompanying illustration has been devised recently by James Beggs & Co., of New York City, for its improved Worthington water-tube boiler, reverberatory-arch furnace type, in connection with an automatic chain-grate stoker.



NEW SETTING FOR THE WORTHINGTON WATER-TUBE BOILER

One of the mud drums is set at a lower level, thus the tubes which connect the two mud drums are inclined at the proper angle to promote circulation and protect the tubes.

The reverberatory arch is formed by covering these tubes at one end with special C-shape fire tile.

The illustration shows the stoker under the lower mud drum, which establishes that side as the front of the boiler.

This arrangement gives ample flame travel and a large combustion chamber above the arch; from the center of the grate to the bottom tubes of the sections the distance is 7 ft.

The furnace has been specially designed to prevent smoke from volatile coal, such as is burned in the Middle West, and possesses the additional advantage of a self-cleaning combustion chamber. By means of a steam blower below the steam drum in the bank of the tubes and one above the arch the soot from the tubes may be blown into the ashpit at the rear of the boiler.

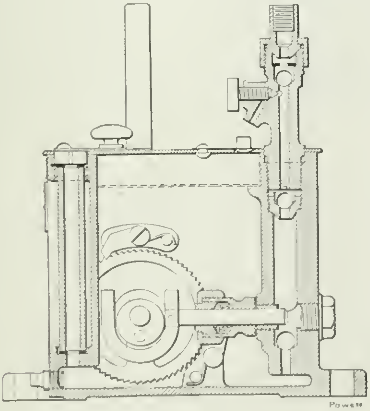
The boiler shown in the drawing is rated at 300 hp. The depth of the setting is 14 ft. 6 in., the width 9 ft. 7 in. and the height from the floor to the top of the steam drum 15 ft. 9 in. With the exception of the width, these same dimensions apply to any boiler between the ratings of 200 and 600 hp., additional capacity being obtained by adding on more sections of tubes to the width.

⁂

McCord One-Feed Lubricator

This class "T" lubricator is so designed that all its working parts run in oil, thus reducing wear to a minimum. It is automatic in action and forces a flow of oil with the first stroke of the engine to which it is attached. The mechanism is shown in the accompanying illustration.

The shaft carrying the ratchet gear also carries an eccentric to give motion to the pump plunger which forces the oil past the two upper ball-check valves, between which is a bleeder showing the quantity of oil being pumped.



Section through Lubricator

The pump, of one-, two- and three-pint capacity, has a heater cast in one corner of the reservoir for heating the oil in cold weather. It is made by the McCord Manufacturing Co., 2587 Grand Boulevard, East, Detroit, Mich.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Washington officials look for an increase in immigration after the war to 24,000,000 new arrivals a year." Gracious Scott! what if one in every twenty-four is an operating engineer!

⁂

Now it is said that one of the nations at war is using the copper parts of old locomotives, including the boiler tubes, in the gun foundries. Some wise geek has been over here and witnessed the high explosiveness of our tubes and cribbed the idee.

⁂

Down Missouri way, it is recommended that every child be given a pig, to be brought up according to pig etiquette. "The boy who sticks to the hog game is headed down Prosperity Avenue," says that state's board of agriculture. Some folks take naturally to hogging it and others have it thrust upon them. This Missouri thing listens like a thrust.

⁂

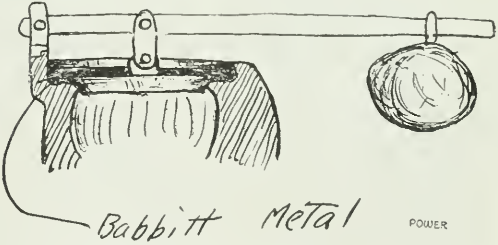
We love our Chicago for many things, but— Well, sometimes it fails to bottle up the enemy. At the teachers' convention an "educator" advised that "O. Henry will take the place of Milton; President Wilson's address to Congress will replace Shakespeare. Shakespeare will be used sparingly, mixed with Bernard Shaw and Oscar Wilde."

Poor old Bill! "Mixed" with B. Pshaw and O. Wilde, Bill will look like a colyum of jokes in Kent's Handbook.

⁂

IN MEMORIAM

A luckless engineer was "Lefty" Wright,
Who thought he'd found a way to make valves tight.



So he "fixed" one with some babbitt
Ere his comrades saw him grab it—
And the pillow that they sent him read: "Good Night!"

⁂

Who says the workman's compensation law does not reach far enough? Only the other day a sufferer got $210 just because his boss set him in contact with a live lobster and neglected to say that the line was not dead. Rubber gloves might have saved a perfectly good thumb-end and 210 passable dollars.

⁂

Here are a few "rules" posted in the engine room of the Globe Iron Co., Jackson, Ohio:

1. When you enter the engine room spit on the floor; we have water, lye, soap, mops and brushes and will clean up as soon as you leave.
2. Rub your hands on all the polished work; it will give some one work and use the surplus polish.
3. Put your hand on the engine's bright work; you will then know if it is smooth, hot or cold. Tell others to do the same.
4. Stay in the engine room as long as you please. The engineer has nothing to do but entertain visitors.
5. Be sure to tell the engineer if his engine is pounding or running right; as he will not know it unless you do. He will stop and make repairs while you wait
6. Don't tell the engineer who you are; he is a mind reader and always knows you. Go anywhere in the engine room and you will please him.
7. Advise him what to do, as you know best; the engineer is there only every day and does not have a chance to see as much as you will in an hour.
8. If the engineer is busy making repairs, tell him a good story you heard the other day, and if possible get in his way

Banquet in a Boiler Furnace

It is not uncommon to read of banquets held amid unusual surroundings, generally typifying the object of the occasion; but in serving a dinner to forty-six persons inside a boiler furnace, the Edison Illuminating Co. of Detroit appears to have eclipsed all previous efforts.

The occasion was the celebration of the completion of boiler No. 1 at the new Conners Creek plant of the company. This boiler is similar to the nine already in operation at the Delray station, which have already been described in these columns. They are the largest boilers in the world, and in the new plant each will regularly supply 10,000 kw. at the turbines. The setting occupies a space 30 ft. cube, and an idea of the size of the furnace will be had from the photograph. The combustion chamber was floored over and the guests were admitted through the ashpit, a section of the dump grate having been removed to permit installing a flight of stairs. The streamers were hung for decorative purposes, but follow approximately the line of the tubes.

Guests Assembled in Boiler Furnace

* * *

Regulations Governing Refrigerants in New York City

The following regulations of the fire prevention bureau of the New York City fire department go into effect Jan. 1, 1915.

REFRIGERATING PLANTS AND REFRIGERANTS

Section 490-A: It shall be unlawful to operate within the City of New York any plant producing refrigeration by means of gases under pressure in connection with cold-storage plants, breweries, ice manufactories, hotels, restaurants or other places without a permit from the fire commissioner.

Section 490-B: Each refrigerating plant shall be equipped with an emergency pipe or pipes by which, in case of accident, the pipes under pressure can be discharged by a valve, which can be opened both inside and outside of the refrigerating plant into water, or be brought into contact with sufficient water to absorb and carry off all gases so discharged. At the discretion of the fire commissioner, the said emergency pipe or pipes may conduct the gases to a point at least 10 ft. above the roofs of adjacent buildings into the open air.

Section 490-C: All refrigerating machines shall be equipped with automatic safety devices, which discharge at 300 lb. pressure to the square inch for ammonia, 1400 lb. for carbon dioxide, 100 lb. for sulphur dioxide, and 100 lb. for ethyl chloride into the emergency pipes required by the preceding section, or into the low-pressure side.

Section 490-D: In refrigerating plants built and erected after Jan. 1, 1915, every room containing pipes carrying a refrigerating chemical under pressure exceeding 40 lb. for ethyl chloride, 60 lb. for sulphur dioxide, 100 lb. for ammonia and 500 lb. for carbon dioxide, and which by accident may become filled with the gases generated by said chemicals, shall have an exit to the open air direct or by means of stairway, or to a room or hall from which said gases can be excluded. Other refrigerating plants shall be provided with such means of exit as the fire commissioner may prescribe. Rooms which contain only the liquid supply pipe to the refrigerating coils are not included within the meaning of this section.

Section 490-E: The maximum pressure allowed in refrigerating machines shall not exceed 300 lb. for ammonia, 1400 lb. for carbon dioxide, 100 lb. for sulphur dioxide and 100 lb. for ethyl chloride. All pipes used for refrigerating purposes shall stand a hydrostatic test of at least double the maximum pressure per square inch specified under Section 490-C. All fittings used must be guaranteed to stand a pressure of at least three times the maximum pressure per square inch specified under Section 490-C.

Section 490-F: No room containing refrigerating pipes under pressure shall have in it any open flame, arc lights or direct openings into the boiler room. There shall be a wall between such room and the boiler room equipped with a self-closing door. Internal-combustion engines may be started in the usual manner.

Section 490-G: In such large refrigerating plants as may be designated by the fire commissioner, there shall be kept, fit and available for use, suitable helmets which will permit the wearer to reach, without suffocation, any part of the refrigerating system.

Section 490-H: In all refrigerating plants the pipes in the engine room shall have conspicuous signs displayed at proper places designating in easily legible letters the name of the refrigerating chemical contained therein.

Section 490-I: In all refrigerating plants there shall be posted several copies of a brief set of rules satisfactory to the fire commissioner, directing all employees as to their duties in case of fire or other emergencies. Employers shall be responsible for the proper drilling of all employees in such emergency duties.

Section 490-J: Refrigerating plants may store a surplus stock of the refrigerating chemical of two cylinders, or, if necessary, a quantity not to exceed 10 per cent. of the charge of the plant. No cylinder containing gas under pressure shall be stored in the boiler room.

Section 490-K: No refrigerating machine of over three tons refrigerating capacity shall be operated unless under the charge of a person holding a certificate of fitness from the fire commissioner.

Section 490-L: Fire department fee for permit—10 tons refrigerating capacity or less, $2; 10 to 50 tons refrigerating capacity, $5; over 50 tons refrigerating capacity, $10.

Section 490-M: The fire commissioner may exempt from the provisions of these regulations refrigerating machines of less than three tons refrigerating capacity, provided a certificate of approval has been issued for such machines.

[Editorial comment on these rules is made on page 849 of this issue, and the discussion of them before the recent meeting of the American Society of Refrigerating Engineers appears on page 866.—EDITOR.]

Mechanical Engineers' Convention

The 35th annual meeting of the American Society of Mechanical Engineers, held at the Engineering Societies Building, New York, Dec. 1-4, emphasized more than has any previous meeting, the relation of the engineer to the body politic, and the importance of the engineer in the public service. It enlisted interest and attracted attention, therefore, from a wider circle than have meetings devoted more strictly to the methods and details of the work of the profession, and should have an important effect upon the progress of the movement to obtain a wider appreciation and recognition of the engineer as a factor in big enterprises and in public affairs.

The keynote to this was sounded in the address of the retiring president, James Hartness, which dealt with "The Human Element—the Key to Economic Problems." An entire day was devoted to a Public Service Session, which was opened by Hon. John Purroy Mitchel, mayor of New York; addressed by Andrew Carnegie, and attended by mayors, commissioners and the heads of many municipal departments. The committee appointed by the Society to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for their Care in Service presented a progress report, the discussion of which occupied the attention of the whole Society during Wednesday forenoon and continued in well attended sessions throughout the week. The code which this committee is preparing is designed to be the basis of uniform legislative regulation in all the states. Such regulation involves many interests, is accepted reluctantly by some, while all are keenly watchful for features which may possibly affect them prejudicially. It has been a harrowing task to overcome opposition, to reconcile conflicting interests and to evolve a code which should eliminate doubtful design and construction and favor safe and intelligent operation without putting an insupportable burden upon present installations and the users of existing methods, but the hearings of this meeting were characterized by an evident acceptance of the fact that the work must be done, and by a united effort to do it in the best possible manner, so that, as Chairman Stevens expressed it, "we may have in the future a little better boiler for a little more money and less reckless disregard for human life."

It is expected that the committee will be able to present its recommendations, revised in the light of the discussions and in final form at the spring meeting of the Society.

The meeting was not lacking in more technical material. The papers interesting to "Power" readers: "The Design and Operation of the Cleveland Municipal Electric Light Plant," by Frederick W. Ballard, engineer of construction for the plant; "A Rate Flow Meter," by H. C. Hayes; "Laboratory for Testing and Investigating Liquid Flow Meters of Large Capacity," by W. S. Giele, of the Harrison Safety Boiler Works; "A New Volume Regulator for Air Compressors," by Ragnar Wikander; "The Clinkering of Coal," by Prof. Lionel S. Marks, of Harvard University, and "Damages for Loss of Water Power," by F. W. Dean, as well as the discussion of the Boiler Specifications Code, will be treated in future issues.

OPENING SESSION

The formal opening of the meeting took place Tuesday evening with the address of President James Hartness, an abstract of which follows:

THE HUMAN ELEMENT—THE KEY TO ECONOMIC PROBLEMS

In his address on the above subject the president points out that the world of mechanism has become so intricate and complex that it has gone beyond the capacity of any single individual, that each one must be content to comprehend only a small part, and that it is only by selecting the character and limiting the amount of material that is taken into our individual minds that we can hope to accomplish the best results. We should not overload our minds with data to the exclusion of thoughts of an initiative character.

Man is a creature of habit, and the most efficient use of mind and body demands a scheme of life that permits each one to take advantage of this fact. Specialization and repetition, by which habit is formed, are both essential to success.

Carrying the principles of the individual into the realm of organized industry, it is a fact that large organizations are essential as affording an opportunity for the most complete subdivision of work and the greatest degree of specialization, both of which lead to the most effective employment of human energy. Antagonism to the large organizations should be directed against corrupt practices, and not against the organization itself, which involves the workers' interest. The greatest good to the greatest number requires that we take into consideration each human being, his desires and his needs in finding the work for which he is best endowed.

The large industrial plant, to be ideal, should have a capital as large as any competing organization, a small harmonious board of directors with an able leader, and an able staff of officers, the chief executive of which should combine a knowledge of the technical and business side of the industry with the fullest possible conception of the human element. Long continuity in service should be given the first place in the scheme of management. Each position throughout the entire organization should be filled with someone who considers that position the best in the world for him. Each officer and each workman should have a live interest in his part of the work. Each one should by specialization become the most efficient in his particular work. The interest of the officer or worker should be maintained by some fitting stimulus, and each one should be protected so far as possible from influences calculated to induce discontent.

Surely the investor should look with distrust upon a management that is always changing officers, changing men, changing models, changing methods without regard to the inertia of habit and the human element which is the life blood of every organization. He would also look with doubt on any scheme of management that allows the careless employment and discharge of men without due regard to the loss involved by such changes, for the perpetual changing of men is equivalent to the change of character of work in its handicap to industrial efficiency.

Following the address came the report of the tellers of election of officers, which announced the election of Dr. John A. Brashear as president; Henry Hess, James E. Sague and George W. Dickie as vice-presidents, and Charles T. Main, Spencer Miller, Max Toltz and Morris L. Cooke as managers.

The annual reception to the president, president-elect, members and guests, followed by dancing and a collation in the Society's rooms, concluded the evening's program.

WEDNESDAY

After the business meeting on Wednesday morning, the professional sessions opened with the following papers: "Floor Surfaces in Fireproof Buildings," by S. E. Thompson; "Reinforced Concrete Factory Buildings," by F. W. Dean; "Measuring Efficiency," by H. L. Gantt; "Standardization in the Factory," by C. B. Auel; "Operation of Grinding Wheels in Machine Grinding," by G. E. Alden, and "Friction Losses in the Universal Joint," by P. F. Walker and W. J. Malcolmson.

At the simultaneous session of the railroad section, the report of the sub-committee on railroads was submitted, dealing with "Steam Locomotives of Today."

The ladies held a reception and Thé Dansant from 4 to 6 p.m. in the Society's rooms.

Wednesday evening the award of the John Fritz Medal was made to Prof. John E. Sweet, of Syracuse, N. Y., honorary member and past-president of the Society, "in recognition of his achievements in machine design and his pioneer work in applying sound engineering principles to the construction and development of the high-speed steam engine."

Addresses were delivered by Dr. James Douglas, honorary member and past-president of the American Institute of Mining Engineers, and Dr. S. W. Stratton, director of the Bureau of Standards.

THURSDAY

A new feature of the professional program was a session devoted exclusively to public-service problems. This occupied all day Thursday and was opened with an address by Mayor Mitchel, of New York, who spoke on the important rôle of the engineer in municipal affairs. In this connection, he referred to the Bureau of Efficiency which he established some time ago and which has done excellent work in eliminating lost motion among the city departments and in standardizing methods, costs, etc. This is essentially an engineering bureau.

Following the mayor, Andrew Carnegie made a few remarks on the debt which society in general owes the engineer, and then indulged in a few pleasantries with President-elect Brashear, who replied in kind.

The first regular paper of this session was prepared by Henry Bruère, city chamberlain, who dealt with "The Future of the Police Arm from an Engineering Standpoint." Considered in their special applications, police work and engineering appear to have little in common, but as viewed in a broader sense, Mr. Bruère pointed out the urgent necessity for engineering methods in police work; that is, the latter should be developed on scientific lines, and in place of cunning and cudgels there must be substituted a policy based upon a knowledge of needs, feasible standards of service and an organization capable of attaining them.

Morris S. Cooke, Director of Public Works, City of Philadelphia, next spoke on "Some Factors in Municipal Engineering," calling attention to the opportunity for engineers in municipal work and to the fact that at present a large part of this field is covered by nontechnical men. Contrary to the theory of civil service, the best men seldom apply for the more important positions, and it then becomes necessary to go out and find them, offering such inducements as will attract the right man for the place. In such cases, the appointing officer, through some form of merit system or otherwise, should be given a freer hand in making selections. As a safeguard, the author believed the four national engineering societies might act in an advisory capacity to federal, state and municipal civil service commissions.

Further, the effectiveness of the engineer in public employ is largely dependent upon the support accorded him by his profession in the education of the public to proper policies of administration. Too many matters that should be determined by technical and scientific considerations are now decided by vote, of which the control of the budget in many municipalities affords a striking example.

As a citation of one instance in which the engineer is being properly recognized, Edward Flad offered extracts from the new charter of St. Louis, by which a Board of Public Service is created, composed of a president and four directors, two of which must be engineers of technical training.

"The Engineer and Publicity" was the title of the next paper. In this, C. E. Drayer, of Cleveland, pointed out the opportunity of rendering service to the public by giving it dependable information about technical subjects. One reason for the general lack of engineering news in the daily newspapers is that the ordinary reporter lacks the necessary technical knowledge to handle it. The speaker referred to the excellent work now being done by the Cleveland Engineering Society in coöperating with the editors of local papers and supplying engineering items of a popular nature. He believed the work might be extended and carried on broadly through the medium of magazines, pamphlets and the lecture platform, in addition to the daily newspapers.

A paper that attracted unusual attention was "The Design and Operation of the Cleveland Municipal Electric Light Plant,"* by F. W. Ballard. This 25,000-kw. plant, the largest of its kind in the country, went into operation last July and supplies not only city light and power, but also commercial service at extremely low rates, ranging from a maximum of 3c. to a minimum of 1c. per kw.-hr. Based on an annual output of 60,000,000 kw.-hr. and a total plant investment of $3,000,000, the fixed charges, at 9 per cent., would amount to $0.0034 per kw.-hr.; the coal at $0.002 per kw.-hr.; the station costs exclusive of coal at $0.0015, and the distribution costs, exclusive of fixed charges, at $0.004 per kw.-hr. Adding to this, administration charges at $0.0005 and profits at 8 per cent. on the investment, makes the total average cost per kilowatt-hour generated, $0.0165.

The past three months' operation of the plant and the tests that have been conducted indicate that these estimates will be attained.

The remaining papers of this session were "The Handling of Sewage Sludge," by George S. Webster; "Training for the Municipal Service in Germany," by C. L. King; "A Study of Cleaning Filter Sands with no Opportunity for Bonus Payments," by S. E. Thompson, and "Snow Removals" from a report of the committee on resolutions of the Snow Removal Conference, held last spring in Philadelphia.

Simultaneous with the Public Service meeting on Thursday were sessions on iron and steel and on cement. The papers of the former consisted of "Factors in Hardening Tool Steel," by J. A. Mathews and H. J. Stagg; "Standardization of Chilled Iron Crane Wheels," by F. K. Vial, and "The Mechanical Elimination of Seams in Steel Products, Notably Steel Rails," by R. W. Hunt. Only one paper was presented at the cement section, namely, "Electric Drive for Economic Operation and Development of Cement Mills," by J. B. Porter.

The main social event of the meeting was the dinner-dance held in the grand ballroom of the Hotel Astor, Thursday evening. The dinner was a novelty, being a progressive one, in which the couples moved from table to table at the end of each course, and in each interval between the courses there were three dances. Dancing continued after the end of the dinner. The affair was a marked success, showing that the innovation was appreciated. Heretofore the Reunion, as this evening's affair is designated, has taken the form of a dinner or a dance, but this year they were combined.

FRIDAY

The first paper of the Friday morning session, by H. C. Hayes, described a new type of rate flow meter which operates in accordance with the relation connecting the flow and the resulting difference in pressure between the surface and the axis of a spiral vortex. The meter is as simple as the venturi or pitot forms, consisting of a cylindrical chamber terminating in a cone at one end, with the other end capped. The fluid enters through a tangential inlet, thus imparting a vortical motion to the contents of the chamber, and leaves through an axial outlet into which the cone terminates. The low-pressure tap is taken out through the center of the top cap and the high-pressure tap through the side of the chamber. There are no moving parts.

"A Laboratory for Testing and Investigating Liquid Flow Meters of Large Capacity," by W. S. Giele, was the next paper, which was followed by the description of a "New Volume Regulator for Air Compressors," by Ragnar Wikander. This regulates the amount of intake air for air compressors with automatic or poppet type of valves. In order to decrease the amount of intake air, the suction valves are kept open by force during a part of each discharge period, thereby allowing part of the air which has been drawn into the cylinder during the suction period to return through the valves, which close as soon as the amount of intake air remaining in the cylinder has decreased so as to correspond to the amount of compressed air required at the time.

The next paper was by P. F. Walker, on "Physical Laws of Methane Gas," which was followed by a discussion of the "Clinkering Properties of Coal," by L. S. Marks. This as well as the concluding paper of the session, "Damages for Loss of Water Power," by F. W. Dean, will be treated more fully in a later issue.

James Hartness

James Hartness, president of the American Society of Mechanical Engineers for the year 1914, was born in Schenectady, N. Y., in 1861. The first twenty years of his life were spent at Cleveland, Ohio, where after graduating from the public schools he began practical work in machinery building plants. For the next three years he held a position as foreman of a manufacturing plant in Winsted, Conn., and for the four years following was with a hardware manufacturing plant in Torrington, Conn., where he finally served as inventor.

James Hartness, Retiring President of the American Society of Mechanical Engineers

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*This paper will be abstracted more fully in a later issue.

In the fall of 1888, Mr. Hartness designed machinery for the Jones & Lamson Machine Co. at Springfield, Vt., and shortly afterward took an active part in the management of this company. He served successively as superintendent, manager and, for the last dozen years, as president. During this period he has become one of the most prominent manufacturers in New England and one of the most widely known engineers in the country, particularly in the machinery building industry, through the invention and manufacture of the flat turret lathe and of various other machines and tools for turning metal.

In 1910 he invented the turret equatorial telescope, designed to protect the astronomer from the rigors of a cold winter climate. One of these instruments was built, and erected at his residence at Springfield, Vt., and formed the subject of a paper before the Society at the annual meeting of 1910.

Mr. Hartness became a member of the American Society of Mechanical Engineers in 1891. He is a fellow of the American Association for the Advancement of Science, and a member of the Institution of Mechanical Engineers, the Verein deutscher Ingenieure, the Astronomical and Astrophysical Society of America, the London Astronomical Society, the Royal Arts Society, the Boston Chamber of Commerce, and is a vice-president of the Western New England Chamber of Commerce. He was granted an honorary degree of M. E. by the University of Vermont in 1910.

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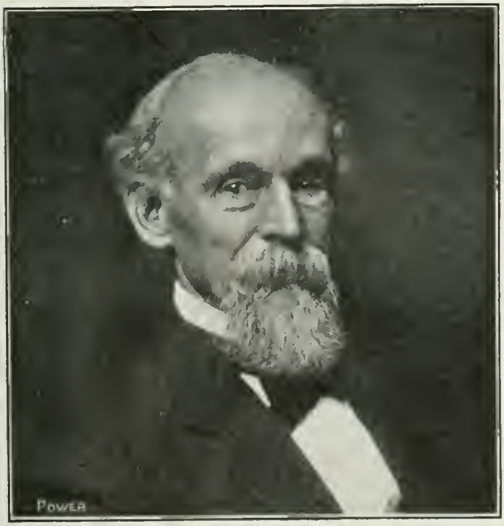
John A. Brashear

John A. Brashear, the newly elected president of the American Society of Mechanical Engineers, is known throughout the world as a manufacturer of astronomical and physical instruments. He was born in Brownsville, Penn., in 1840, and received what little formal education he had in the public schools. After learning the trade of patternmaking, at the age of twenty-two he was established, apparently for life, as a millwright in a Pittsburgh rolling mill.



Dr. John A. Brashear, President-Elect of the American Society of Mechanical Engineers

But he was not content to work only for his bread and butter. He and his ambitious young wife spent their evenings studying astronomy. Having no money to buy a telescope they made one for themselves. Their first glass, a five-inch one, took three years to grind. Unsatisfied with its limitations, they set to work on a twelve-inch glass, only to have it break in the silvering process after two years of grinding and correcting. The next glass proved successful, and was the turning point in young Brashear's career. Langley, then in charge of the Allegheny Observatory, began to entrust him with some of the observatory instruments. At the same time, certain astronomical articles which Brashear had written attracted the attention of William Thaw, one of the patrons of the observatory, and he advanced the capital so that Brashear might move to Allegheny and set up a shop there.

Brashear's greatest work in the field of science began with this move to Allegheny. An account of the accomplishments of his shop would be a history of modern astronomy. Perhaps his most important achievement has been in connection with the design and development of the spectroscope for astronomical uses, particularly with reference to the mechanical features.

Mr. Brashear's more purely scientific work also brought recognition, and about the time of his removal to Allegheny he was given an appointment in the University of Western Pennsylvania of which the Allegheny Observatory was a department.

The John A. Brashear Company, Ltd., which Dr. Brashear formed with his son-in-law, James B. McDowell, in Allegheny, has been devoted to the construction of apparatus for special work, rather than more commercially profitable products. The firm has no patents and no secrets, and whatever it has accomplished it has freely given to the world. The Allegheny Observatory, which has long been Dr. Brashear's special hobby, is also unique, in that it is at the disposal of the public, through lectures and through access to the telescope and other similar means. For a number of years past he has been a trustee of the Carnegie Institute of Technology.

Dr. Brashear acted as director of the Allegheny Observatory from 1898 to 1900. He is a fellow of the American Association for the Advancement of Science and the Royal Astronomical Society of Great Britain; is a past-president of the Engineers Society of Western Pennsylvania and the Pittsburgh Academy of Arts and Sciences; and is a member of the British Astronomical Association, the Société Astronomique de France, the Société Astronomique de Belgique, the American Philosophical Society, the Astronomical and Astrophysical Society of America, the National Geographic Society, and an Honorary Member of the Royal Astronomical Society of Canada. He has been honored with the degree of LL.D by Washington and Jefferson College and by Wooster University, and with the degree of Sc.D. by Princeton University and the Western University of Pennsylvania.

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John Fritz Medal Awarded to John E. Sweet

Dr. Sweet, the recipient of the John Fritz Medal award this year, first became a national figure from his connection with the Sibley College of Mechanic Arts of Cornell University in 1873. This lasted only until 1879, but in that time he became prominent for his work in mechanical engineering education, which was then a new thing

Dr. John Edson Sweet, Honored with the John Fritz Medal Award

He next turned his attention to improvement in methods of mechanical construction. Combining an appreciation of Whitworth's advanced standards of accuracy with original conceptions of fundamentally correct principles of construction of a kind far surpassing Whitworth's work, he established a school of construction of which the influence has been far reaching. Along with this went an application of art in design—not the art of ornamentation, but that of perfect adaptation to purpose. His Straight-Line engine was an embodiment of these principles.

Dr. Sweet was born Oct. 21, 1832, at Pompey, N. Y., his mechanical talent being an inheritance through his mother. His introduction to mechanical work was through his apprenticeship to the carpenter's trade, from which he developed as a builder and architect. In 1862 he went to Europe and for a time worked in England as a mechanical draftsman. Returning in 1864, the peculiar individuality of his work soon began to manifest itself, his most ambitious production of this period being a typesetting machine which is still preserved at Cornell University. Later, he was engaged in bridge building for Howard Soule, from which work he was drafted to the Cornell shop, where his pioneer work in accurate measurements was done. This with other examples of student workmanship was exhibited at the Centennial Exposition, where it attracted world-wide attention. The Straight-Line Engine Co., with which his name has been identified, was organized soon after leaving the university. It was his suggestion which led to the organization of the American Society of Mechanical Engineers, of which he was the third president.

Refrigerating Engineers Meet

The tenth annual meeting of the American Society of Refrigerating engineers was held in the Engineering Societies Building, New York City, Nov. 30 and Dec. 1. Three sessions were held on Monday and two on Tuesday. For the two days of the meeting luncheon was served in the Engineers Club, while a fine banquet in the College Room of the Hotel Astor completed the meeting.

In his address, President Henry Torrance urged wider dissemination of refrigeration data, and recommended continued care in admitting new members so as to keep the membership on a high professional standard.

The new Journal of the society, introduced at this meeting, consists of 125 pages of the usual 6x9-in. size. It contains four of the papers read at the meeting and has a review section of twenty-one pages. There was considerable discussion as to whether the Journal should be available to members only or to all who wished it. It was finally agreed that nonmembers might obtain copies through members or a publisher. The price to be charged will be fixed by the council.

During the year the fire prevention bureau of the fire department of New York began revising its regulations applying to various businesses and industries, and invited the society to appoint a committee to confer with it in the revision of its regulations applying to ammonia and other refrigerants. Revision was completed and the regulations (see this issue, page 862) will go into effect on Jan. 1, 1915.

The second section of the regulations requires that a plant shall have a pipe or pipes by which lines under pressure may discharge into water or conduct the gases to a point not less than ten feet above the roofs of adjacent buildings.

F. L. Fairbanks, of the Quincy Market Cold Storage & Warehouse Co., Boston, who is assisting the Massachusetts Board of Boiler Rules in formulating regulations similar to those of the New York fire department, commented on this section. His argument was that in most plants it is not practically possible to comply with the section, for it requires a considerable body of water to absorb ammonia discharged in case of severe accident. Unless the body of water were a harbor or a river it would soon become saturated and useless as an absorbent. He pointed out that a body of ammonia gas has the peculiar property of remaining intact when floating over a wide area. This was demonstrated to him, when, owing to a break in a 6-in. suction line in the Sargent's Wharf plant* at Atlantic and Eastern Aves., Boston, several families were driven out of their homes in East Boston, across the harbor from the plant. Therefore, the discharge of much ammonia near open windows of adjacent buildings would be decidedly dangerous.

Mr. Fairbanks cautioned against agreeing to the third section of the regulations, which says: "All refrigerating machines shall be equipped with automatic safety devices (meaning safety valves, chiefly) which discharge at 300-lb. pressure for ammonia, 1400 lb. for carbon dioxide, 100 lb. for sulphur dioxide, and 100 lb. for ethyl chloride. He stated that, to begin with, he had every reason to believe that there was not a tight safety valve for ammonia on the market.

Therefore, the use of safety valves that leak frequently leads the engineer to plug them to avoid a loss of part of the ammonia charge. Again, the Massachusetts Board of Boiler Rules had demonstrated in Mr. Fairbanks' plant that the pop type of safety valve so suddenly liberates ammonia gas that there is little likelihood of persons getting out of the room into which the gases are discharged. This board, Mr. Fairbanks said, will not permit, on ammonia compressor heads, the use of safety valves set to blow at 400 lb. into a pipe having a safety valve set at 200 lb. and discharging into a receiver. The question of the disposition of escaping ammonia gases and of safety valves is so serious that the board has not yet solved it. After hearing this report, President Tor-

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*For description of this plant see "Power," Dec. 8, 15, 22, 29 and Jan. 1.

Banquet of the American Society of Refrigerating Engineers rance continued the New York committee and added the name of Mr. Fairbanks inasmuch as his experience showed that the refrigerant regulations of New York City's fire prevention bureau had serious shortcomings. In view of this it would seem that New York City would do well to coöperate with the Massachusetts Board of Boiler Rules. We editorially comment on this on page 849 of this issue.

The committee under Dr. Dannenbaum, of Philadelphia, formed to investigate the sources and compositions of foreign gases in refrigerating systems made a preliminary report. In several cases analyses of the gases showed them to contain from 91 to 95 per cent. nitrogen, the balance being oxygen That the presence of much of the foreign gases is due to the volatilization of the lubricating oils is shown by the fact that the committee was not able to find a natural American oil that would not crack at commercial compressor temperatures. One Russian oil subjected to temperatures higher than met in practice could not be made to crack.

In this connection it is interesting to note that one eminent authority has stated, not publicly, that tests of this nature—i.e., where the oils are subjected chiefly to a heat test to indicate characteristics of volatilization—may not lead to accurate conclusions, for the tests do not consider the effect of impact of the oil at each stroke. The Bureau of Standards is coöperating with this committee, and it is hoped that next year a valuable and interesting report will be presented. Relative to the cold tests of oils, some oil companies, or at least the Standard Oil Co., is removing the wax from paraffin-base oil by first cooling it, and while at —10, —20, or —30 deg. F., squeezing out the wax. In other words, what nature has done in Russia the Standard Oil Co. is endeavoring to do here.

President Torrance read a short paper on ammonia condensers, but was justly censured for not having been thorough enough in his tests. The paper on ammonia condensers by Fred Ophüls, of New York City, was thorough and scientific. It should be noted, however, that Mr. Ophüls' purpose was to stimulate investigation into the causes that affect the efficiency of ammonia condensers, by stating test results and by giving theoretical deductions, the latter requiring further consideration for accuracy before acceptance.

Unfortunately, it is the practice in the society to read papers, even though they are already published in the Journal, instead of reading abstracts only, so Mr. Ophüls' paper was not discussed, because the reading of it used all the time available.

The objection to reading the entire paper was even more pronounced when the excellent paper on cooling towers by B. H. Coffey and George A. Horne was presented. Relative to the important problems in meteorology and engineering involving the humidity of climates and the evaporation losses in reservoirs and lakes, the subject was shown to be not only extremely complex, but that a suitable mathematical expression for evaporation to the atmosphere was still lacking despite the fact that the bibliography comprises more than eight hundred publications, dating from 1670 to the present.

Mr. Coffey told how ice is formed under peculiar conditions in India in places near the Himalayas. A pit two feet deep is filled with rice straw to within six inches of the top. On top of the straw cups of water are placed. With an atmospheric temperature of 50 deg. or less, and when a north-northwest wind or one coming from the mountains blows, ice forms. But with much lower atmospheric temperatures and other wind directions ice cannot be made to form. The air from the mountains is low in humidity and as the tops of the cups are six inches below the ground surface, a blanket of dry air is present. The evaporation of this water to that air is rapid enough to cause freezing.

A paper by R. S. Broas, of New York City, on rotary compressors for refrigeration was then read. Mr. Fairbanks found that with most compressors built on the design of the Kinney pump serious shocks were produced owing to the unbalance due to the "long side" of the cam-shaped rotor. He overcame this to some extent by extending the shaft and mounting on it another rotor outside the casing and with its "long side" opposite that of the other rotor.

Mr. Shipley, of the York Manufacturing Co., said that his company had tried out in its testing plant all available rotary compressors, but found none that was commercially applicable to general ammonia compression. It was the general opinion of those present that rotary compressors were unsuited to any but low-pressure service, such as booster work.

The last and most interesting paper read was by F. L. Fairbanks, who took as his subject the design, construction and operation of a 1000-ton ammonia compressor. As this machine, as well as all of the important engineering practice in Mr. Fairbanks' plant, is described in a series of articles in "Power" for Dec. 8, 15, 22, 29, 1914, and Jan. 5, 1915, we refer the reader to them.

So much time was consumed with the reading ot papers that there was little topical discussion, often so valuable. An interesting one was given by Dr. F. W. Frerichs, of St. Louis, on the manufacture of cylinders for shipment of ammonia.

That well known happy toastmaster, Theodore O. Vilter, of Milwaukee, presided at the banquet. Among the speakers were Louis Block, inventor of the Block condenser; John E. Starr, Thomas Shipley, Prof. C. E. Lucke, of Columbia University and Mr. Freeman, of Boston. Prof. Lucke drew the fire of Mr. Starr by charging refrigeration engineers with little or no progress in extending the application of refrigeration to the industries. The professor was severe in his criticism. Mr. Starr, in defense of the art, mentioned the Eastman Kodak Co., of Rochester, N. Y., as one noteworthy example of the application of refrigeration. He stated that an advance had been made in the amount of ice produced per ton of coal. A few years ago it was but six and seven; today it is twenty and more. Then too there is the application of refrigeration to metallurgy, the paraffin industry, cooling of magazines aboard warships, cooling of batteries in submarines, etc.

The fourth Western meeting of the society will be held in San Francisco, 1915, concurrent with the International Engineering Congress.

Louis Doelling, president of the De La Vergne Machine Co., was elected president; Ezra Frick, vice-president; George A. Horne was retained as treasurer.

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California Agreement on Water Power Development of National Forests

The Secretary of Agriculture and the state water commission of California have entered into a coöperative agreement for the use of water-powers within the national forests of that state. It is announced that questions which have been pending for some time are effectually settled by this agreement.

The district forester at San Francisco, mentioned in the paper, is the field officer of the forest service who has charge of the administration of the federal forests in California.

The agreement follows in full:

For the purpose of facilitating the approval of applications for water rights and for the occupancy and use of national forest land within the state of California for the development of water-power, and in order that uniform action may be taken with respect to such applications, the Secretary of the United States Department of Agriculture and the water commission of the state of California, subscribe to the following coöperative agreement:

1. Whenever an application for either a preliminary or a final permit for a water-power site is filed with the district forester at San Francisco, Calif., and the evidence of the appropriation of water consists of a notice posted in conformity with the provisions of Section 1415 of the Civil Code of California, immediate notice of such application for a permit, consisting of the name of the applicant, the name of the stream from which the water is to be diverted, the point of the proposed diversion, the date of the notice, and the name of the locator, shall be sent to the State Water Commission.

2. Whenever an application for a preliminary or a final permit is filed with the district forester, and the evidence of the appropriation of water consists of a copy of an application made to the state water commission, or a permit from said commission under the existing Water Power act, it will be sufficient to inform the commission that such application for permit has been filed with the district forester.

3. Whenever an application is made to the state water commission for a permit to appropriate water, and the use of such water will in any manner necessitate the occupancy and use of any national forest land, immediate notice of the filing of such application shall be given to the district forester at San Francisco. Such notice shall give the name of the applicant, the stream from which the diversion is to be made, the point of the proposed diversion, the date of the notice, the name of the locator, and a description of the lands that may be within such national forest.

4. No application for a water right involving the use of national forest lands will be approved by the state water commission prior to notification by the district forester that a complete application (with the exception of evidence of water appropriation) for the use of the national forest lands has been filed in conformity with the regulations of the Secretary of Agriculture.

5. If the application filed with the district forester, as provided in paragraph 4 hereof, is for a preliminary permit, the state water commission will defer final approval of any application for water right until notified by the district forester that a complete final application (with the exception of evidence of water appropriation) has been filed in accordance with the regulations of the Secretary of Agriculture, or that a preliminary permit containing permission to do construction work has been issued. The district forester will confer with the state water commission before arranging the terms of any preliminary permit and will furnish the commission with copies of such permits immediately upon their issuance.

6. If the evidence of the appropriation of water filed with an application for a final permit for a water power site consists of a notice posted in conformity with the provisions of Section 1415 of the Civil Code of California, such permit will not be issued until the state water commission either ap-

proves such appropriation or disclaims jurisdiction. If the applicant relies upon an appropriation under existing law, no final permit will be issued until notice of the approval of the commission has been filed with the district forester.

7. No preliminary permit will allow construction upon national forest land except in an emergency or to comply with the state law, and then only upon approval of the state water commission.

8. If the time for beginning and completing construction under any final permit issued by the Secretary of Agriculture is different from that granted by the state water commission such difference shall not be deemed to affect in any way the permittee's liability under the state law or the approval of the commission, or to free him from the cancellation of his permit if he loses his water right under the state law.

9. If any permittee shall lose his water right because of failure to begin construction in accordance with the requirements of the state law and of the approval of the state water commission, such loss of right when certified to by the said commission shall be deemed sufficient cause for revocation of the permit.

10. If either the district forester or the state water commission shall fail to give notification of any action as contemplated herein, within sixty (60) days of the receipt of written report of applications pending, the officer or office so reporting may take action without waiting further for such notification.

In witness whereof, this coöperative agreement has been executed at San Francisco, Calif., by the state water commission of California, on the twenty-seventh day of August, 1914, and at Washington, D. C., by the Secretary of the United States Department of Agriculture, on the fourteenth day of November, 1914. (Signed) Charles D. Marx, Harold S. Power, S. C. Graham, D. F. Houston, Secretary of Agriculture.

Bill to Create Federal Safety Bureau

The proposed legislation to create a Bureau of Labor Safety in the Department of Labor was held up at the last session of Congress by objection, by Senator Smoot of Utah, to unanimous consent to consider the bill. The bill is still on the calendar and will likely come up for final action early in January, but if not acted upon before March 4, it will expire by limitation

The act would provide authority and means, under the jurisdiction of the Secretary of Labor, to make general and special investigations of safety plans and devices of all kinds and the need therefor, and to gather, publish and supply useful information concerning the use of labor safety devices, etc., in the industries of the United States and elsewhere.

A museum and laboratory are provided for wherein shall be exhibited and tested types of guards, etc., for machinery calculated to safeguard employees and the public from injury. It is so drawn and amended as not to conflict with the work of the Bureau of Mines in the matter of mine safety.

Recent Court Decisions

Digested by A. L. H. STREET

Power Plant Employees as "Fellow Servants"—An employer of a fireman and a coal passer is not liable for damages in a suit for injury to the latter caused by negligence of the former, if the fireman bore a relationship of co-employee to the coal passer, and was not in a position of superintendence over him. (New York Supreme Court, First Appellate Division; Fearon vs. New York Life Ins. Co.; 147 "New York Supplement," 644.)

Extent of Water Power Rights—A conveyance of one tract of land together with water rights and water power privileges in an adjoining tract, as appurtenant to the land conveyed, does not entitle the grantee to use such rights and privileges for the benefit of other land owned by him. This is the gist of the Georgia Supreme Court's decision in the recent case of Central Georgia Power Co. vs. Cornell, 82 "Southeastern Reporter," 243.

Removal of Boiler Inspectors—In an opinion recently given by the attorney general of Minnesota he holds that the governor may remove a boiler inspector at pleasure. Under a recent re-apportionment of the state an inspector was eliminated, and in making a new appointment commission was issued by mistake to William Mitroth, instead of H. E. Olson, the governor's choice. Mitroth refused to resign when the mistake was discovered and the Governor's office called upon the attorney general for an opinion, with the result above mentioned.

Damages Recoverable for Personal Injury—Twelve thousand five hundred dollars is not excessive recovery for injury to a stationary engineer, whose arm and muscles and flesh over his ribs were torn off by being caught in a rapidly revolving pulley while he was applying treatment to the pulley to make the belt cling, if the employer had elected not to be governed by the Workmen's Compensation Act, and negligently failed to take steps to reasonably guard the belt. (Wisconsin Supreme Court, Mayhew vs. Wisconsin Zinc Co., 147 "Northwestern Reporter," 1035.)

Breach of Contract to Supply Water—Where a seller of land agreed to furnish from a water-power plant owned by him a supply of water for use by the purchaser of the land, so long as the purchaser should require it, and the latter made extensive improvements on the faith of the contract, he was entitled, on the seller's breach of the agreement, to recover the amount of the depreciation in the value of the land resulting from such breach. But the purchaser has no lien against the dam property to secure performance of the contract. (Texas Court of Civil Appeals, Abney vs. Roberts, 166 "Southwestern Reporter," 408.)

OBITUARY

DUNCAN D. RUSSELL

His many friends will be sorry to learn of the death of Duncan D. Russell, treasurer of the James Russell Boiler Works, South Boston, Mass. Mr. Duncan succeeded his father, who established the business, and carried it on successfully for many years, and will himself be succeeded by his son. He was ex-president of the Scots' Charitable Society of Boston, treasurer of the New England Association of Boiler Manufactners, and stood high in the confidence of his business associates.

MORRIS G. CONDON

Morris G. Condon, president of the firm of H. B. Underwood & Co., who was robbed and then shot in his apartment at the Hotel Adelphia, Philadelphia, Penn., on Nov. 25, died at the Jefferson Hospital on Dec. 3. His death was due to the abdominal wound inflicted by the bandit, who ended his own life when he believed he had been cornered.

With Mr. Condon at the end was his wife, who had been at his bedside in the hospital almost constantly. Two brothers of the murdered man and an associate in business were present.

Mr. Condon was 51 years old and had a residence at North Wales, Penn. He went to the Adelphia to spend the winter with his wife.

ENGINEERING AFFAIRS

The annual entertainment and reception of the Marine Engineers' Beneficial Association No. 33, of New York City, took place on the evening of Dec. 2, at the Lexington Opera House. The hall was tastefully decorated, and the attendance, as usual, was large. Many prominent engineers and supplymen were present. An interesting entertainment preceded the dance.

The Stationary Engineers' Association of Greater New York held its annual entertainment and ball on Saturday evening, Dec. 5, at the Amsterdam Opera House. Although the weather was unpleasant, the attendance was good. There was a vaudeville entertainment, and dancing concluded the night's enjoyment. The officers of the organization are: John J. Burns, president; Patrick Cody, vice-president; Joseph Cassidy, recording secretary; W. H. Fletcher, financial secretary; Timothy McGarry, treasurer.

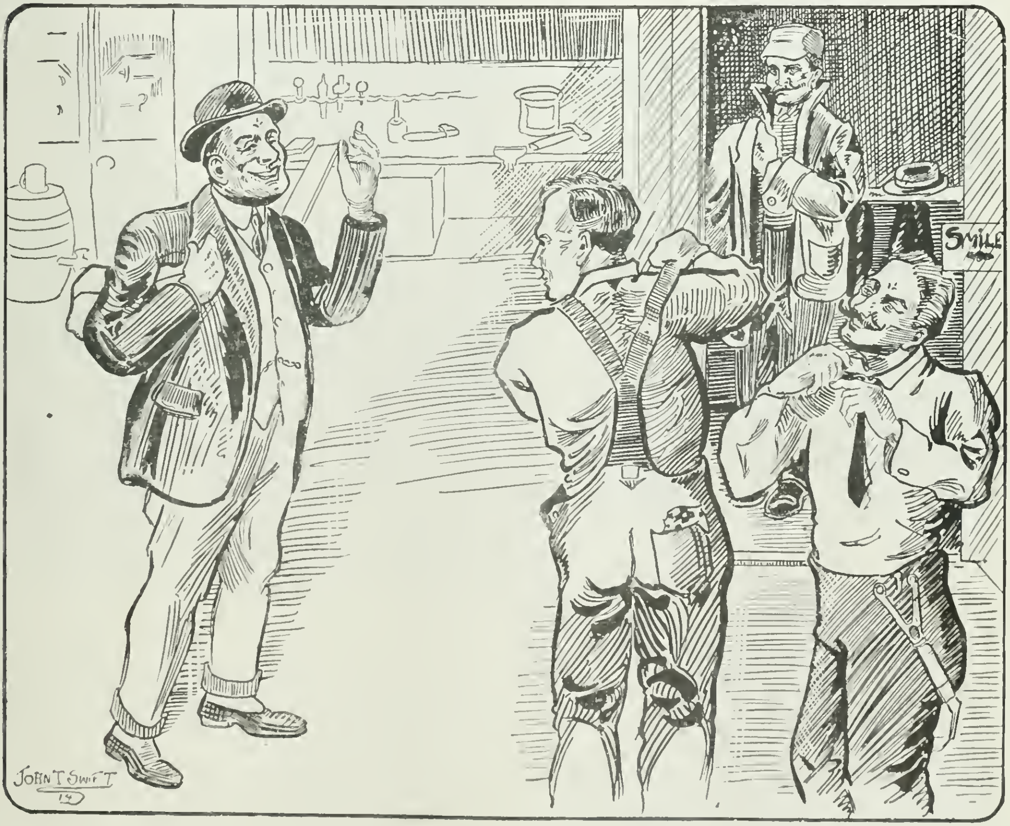
The annual mask and civic ball of the Brooklyn Association No. 56, International Union of Steam and Operating Engineers, was held at the Brooklyn Labor Lyceum, Saturday evening, Dec. 5. There was a long program of dances, and many pretty and unique costumes were shown by the participants. The officers are: Frank Schmitz, president; Charles Schneider, vice-president; Norman C. Ames, recording secretary; Ellsworth Stout, corresponding secretary; George Kurz, conductor; Thomas Sugden, guard; H. Greve, treasurer; C. F. Liebman, organizer; Joseph Muntefering, business agent.

Kneiser Association No. 3, N. A. S. E., has unanimously endorsed Oscar F. Rabbe for the position of chief examiner of steam engineers of Ohio. The association states that "We feel that Brother Rabbe is well qualified for the position. He has for many years been a hard worker and a good booster for the N. A. S. E. as well as for the engineers' examination and boiler inspection legislation, and we hope that other local associations will give him their support also."

POWER

Vol. 40. NEW YORK, DECEMBER 22, 1914 No. 25

"A Merry Christmas Face"



HAVE YOU a vinegar aspect? Do you carry an ingrown GROUCH to work? Forget it. The world hates a "gloom"—a "gloom" hates himself. A smile's worth while. Everyone loves a LAUGHER. Switch sixty-four candle power into your face. Light up with peeping eyes and a good, big, broad grin. Put more of comradeship, of CHEER into that "Good morning, Bill," "Howdy, Jack," "Top o' th' morn, Steve," at the plant tomorrow. A cracker-jack little EFFICIENCY ENGINEER, that old SMILE of yours. Give "him" a tryout and he'll make GOOD. Ever think about it that way?

[Contributed by John T. Swift, Denver, Colo.]

A Detroit Flour-Mill Plant

By Thomas Wilson

SYNOPSIS—This is a 600-kw., single-unit turbine plant carrying a connected motor load of 1080 hp. and 25 kw. in lamps twenty-four hours a day and six days a week. The operating cost per kilowatt-hour is 0.48c.

※

The Commercial Milling Co., Detroit, Mich., has one of the best equipped flour mills in the country, its capacity enabling it to produce 1200 bbl. per day of the Henkel products. In the near future the capacity will be doubled.

The machinery in all departments is of the latest design and for the most part is belt driven from line shafts turned by motors. To the shaft driving the complete series of rolls a 300-hp. motor is connected by a rope drive; a 200-hp. motor drives all of the bolters and purifiers; a 125-hp. motor elevates 10,000 bu. of grain per hour from the basement to the top of the building where it flows to the bins by gravity; a 50-hp. motor operates the marine leg for unloading wheat from the boats; a 35-hp. motor operates an Otis freight elevator, and other motors of 15 hp. and less drive other machinery and elevators in the new mill. In the older mill there are four motors rated at 125, 100, 50 and 10 hp. Fig. 3 shows one of the large motor drives.

All of these motors, totaling 1080 hp., are of the three-phase induction type. For the lighting there are a thousand 25-watt Mazda lamps. The total load runs from 800 to 1050 amp., the current being 903 amp. at normal rating and the voltage 480, for which all of the motors are wound. For twelve months this load has been carried night and day, with the exception of Sundays, by one 600-kw. (at 80 per cent. power factor) generating unit (Fig. 1) consisting of a four-stage, impulse, horizontal turbine coupled to a three-phase generator revolving at 3600 r.p.m. There has been no occasion to shut down for repairs. In case of such a necessity, the mill would come to a standstill as there is no reserve unit of sufficient capacity nor a breakdown connection to keep it running. Sundays and a surplus stock in the mill are relied on to tide over a breakdown. Eventually, a new mill of the same size and another turbine unit will be erected.

A surface condenser containing 1100 sq.ft. of cooling surface maintains a vacuum of from 28 to 28.5 in. on the main unit. Circulating water is drawn from a cold well open to the river by a turbine-driven centrifugal pump. The condenser is protected by a three-unit strainer, Fig. 2, placed on the discharge side of the pump because of lack of room on the suction side. The water is discharged to a hotwell and flows back to the river by gravity. On the same shaft and driven by the same turbine, another small centrifugal pump delivers the condensate to a 1250-hp. open heater in the boiler room, where its temperature is raised to 212 deg. The condenser and the two pumps just mentioned are in the basement, but the 6 and 14 by 10-in. dry-vacuum pump has been placed on the engine-room floor.

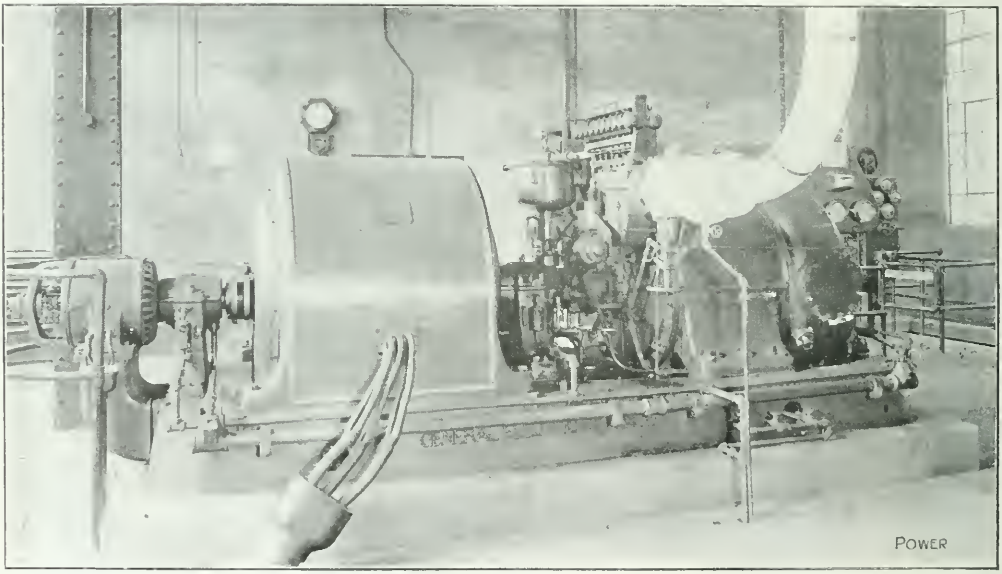


Fig. 1. Main 600-Kw. Generating Unit

To light a large sign on top of the building on Sunday night or at other times when the main unit might be shut down, there is a two-cylinder, 9x11-in. gas engine (Fig. 4) using city gas. This engine is belt connected to a 60-kv.-a., 480-volt, three-phase generator. Of course, this unit may be used to carry a small part of the mill load. Recently it has been planned to throw the generator on the line and run it unloaded as a synchronous motor, the

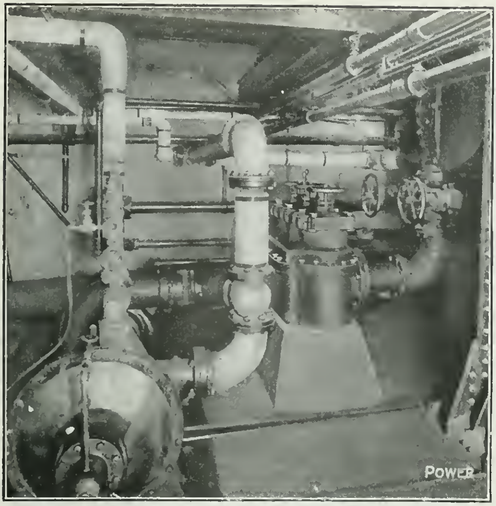


Fig. 2. Connection of the Three-Basket, 12-In. Strainer

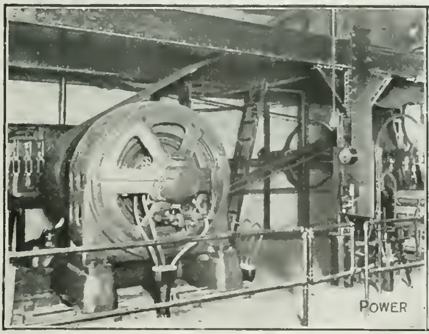


Fig. 3. One of the Large Motor Drives

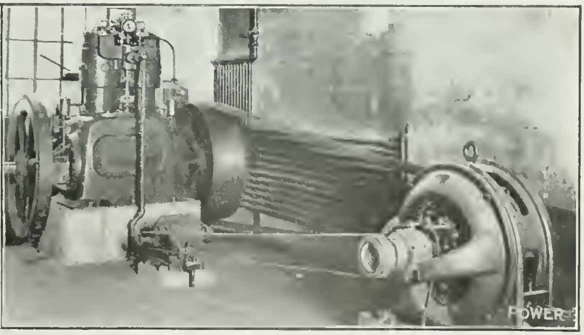


Fig. 4. Gas-Engine Unit

object being to counteract the lagging current caused by the induction motors and thereby improve the power factor.

A standard switchboard (Fig. 5) equipped with the usual instruments serves the generator and feeder circuits, and there is an independent panel for the gas-engine unit. There are the usual ammeters and voltmeters, a Tirrell voltage regulator and four recording meters, for the generator, the motors in the old mill, the 200- and 300-hp. motors in the new mill and a fourth for all of the others. Besides there are gages for recording the boiler pressure and the vacuum.

At present the boiler room (Fig. 6) is equipped with two 350-hp. water-tube boilers, and a third will be installed when additional turbine capacity requires it. The working pressure is 185 lb. and superheaters raise the steam temperature 110 deg. above that corresponding to the pressure. At the turbine the pressure is 175 lb. The boilers are equipped with underfeed stokers which require forced draft, a breeching with one right-angle turn and a 150-ft. brick stack 6 ft. in diameter at the top. The header for the main unit is back of the breeching and underneath it is an auxiliary header for the pumps. The layout is shown in Fig. 7.

There are two feed pumps of the duplex center-packed type and two single-cylinder pumps which draw water from the hotwell and deliver it to the heater in case of failure of the city supply, which is the usual source of makeup water. These pumps, the condenser auxiliaries and the stoker and fan engines give enough exhaust steam to heat the feed water and supply the heating system in moderate weather. The heating system is of the two-pipe gravity type, from which the condensation is drained to a receiving tank and returned to the heater. In the colder months some live steam reduced to 1 lb. pressure is required for heating, and also a small amount for the wheat heater.

Meadow Brook bituminous coal is delivered on a railway siding near the boiler room and motor-operated capstans switch the cars to the location for unloading. The coal is dumped into a hopper and carried by a belt to a bucket conveyor which raises it to the top of the boiler room and drops it into a screw conveyor provided with sliding doors in front of each bunker; there are four in all, with a total capacity of 300 tons. From the bunkers the coal is temporarily shoveled into the stoker hoppers, but this arrangement is to be superseded by concrete bins

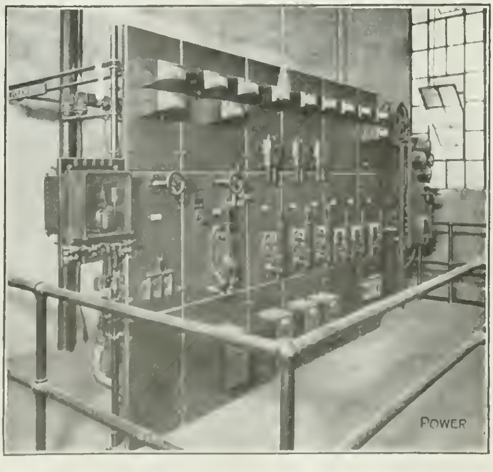


Fig. 5. Switchboard and Gas-Engine Panel

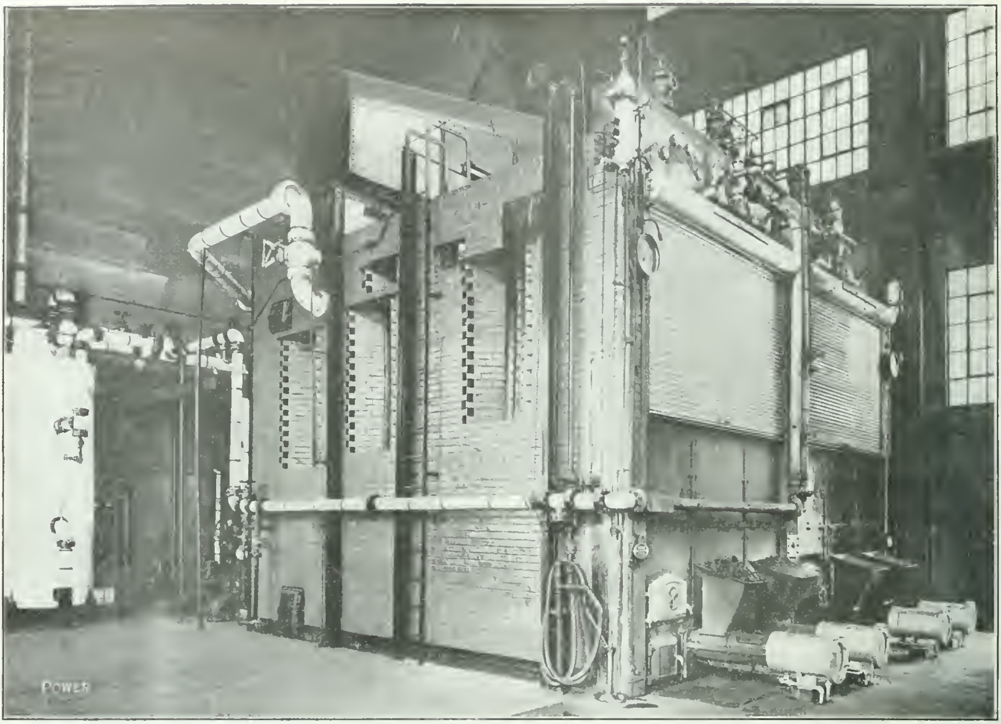


Fig. 6. Two Boilers, with Space for Another Unit

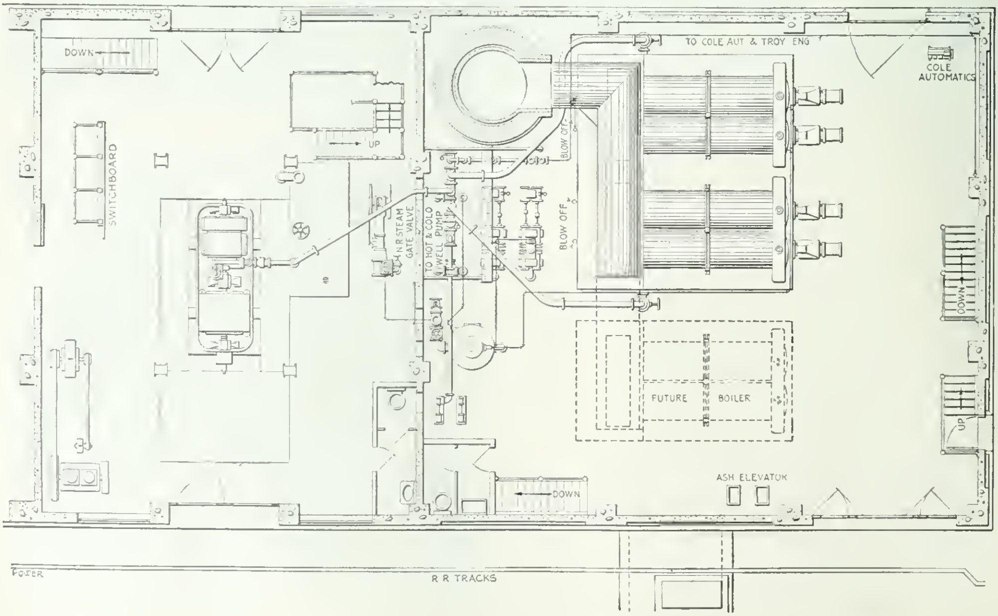


Fig. 7. Plan View of the Power Plant

so raised that the chutes will feed through scales into the stoker hoppers.

Unit Costs

The equivalent of a three-story building houses the power plant and the large motor drives. Its approximate cost was $10,000. The equipment and its installation, exclusive of the gas-engine unit, cost close to $45,000, and 970 hp. in new motors and control equipment cost $13,000. Including the last item, which really does not belong to the power plant proper, the cost per kilowatt of rating amounts to

$$\$68{,}000 \div 600 = \$113.$$

Without the motors the unit cost is reduced to approximately $92 per kilowatt, and for the power-plant equipment and its installation only, the cost per kilowatt is $75. Including the permanent coal bunkers will increase this figure slightly, but by the time another boiler and a second turbine of the same capacity have been installed in the spaces reserved for them, the cost per unit will be lower. At present the turbine capacity is 600 kw. and that of the two boilers is 700 hp., a ratio of 6 to 7, or $1\frac{1}{6}$ boiler-hp. per kilowatt of rating. With the plant increased to three boilers and two turbines, the ratio will be 12 to 10.5, or 0.875 boiler-hp. per kilowatt of generating capacity. At present, one boiler carries the load.

PRINCIPAL EQUIPMENT OF COMMERCIAL MILLING CO. PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbine...	Horizontal impulse	600 kw.	Main generating unit....	175 lb. gage, vacuum $28\frac{1}{2}$ in., 3600 r.p.m....	General Electric Co.
1	Generator.	Alternating current	600 kw.	Main unit........	Three-phase, 480 volts, 3600 r.p.m.	General Electric Co.
1	Condenser.	Surface "Speroflow"	1400 sq.ft.	Serves main unit	River water, vacuum $28\frac{1}{2}$ in	Alberger Pump & Condenser Co.
1	Pump.....	Centrifugal........	8-in..	Condenser circulating water	Driven by 30-hp. Alberger turbine	Alberger Pump & Condenser Co.
1	Pump.....	Standard volute.	2-in..	Condensate pump......	Driven by same turbine as circ. pump...........	Alberger Pump & Condenser Co.
1	Pump.....	Reciprocating.	6x14x10-in.	Dry vacuum pump	175 lb. steam, exh. to heater	Alberger Pump & Condenser Co
1	Gas engine	Vertical, 2 cycle...	9x11-in....	Light large sign.....	Belted to 60-kw. G. E. generator..	Westinghouse Machine Co.
1	Multiple strainer...	Three-basket....	12-in.....	Strain condenser cooling water	Located between pump and condenser............	Lagonda Mfg. Co.
2	Boilers....	Water tube..	350 hp.....	Generate steam......	185 lb. steam, stokers, forced draft	Edge Moore Iron Co.
2	Stokers....	Jones under feed..	....	Serve boilers....	....	The Under Feed Stoker Co. of America
2	Superheaters...	Foster.....		On 350-hp. boilers	110 deg. superheat..	Power Specialty Co.
1	Heater....	Open.....	1200 hp	Heat feed water.	Exhaust from pump and aux...	Perfection Heater & Purifier Co
2	Pumps....	Duplex...	10x6x12-in.	Boiler feed water.	185 lb. steam...	Dean Bros. Steam Pump Works
2	Pumps....	Simplex.	8x7x12-in..	Pump from hotwell to heater	185 lb. steam......	Dean Bros. Steam Pump Works

Switchboard and all motors furnished by the General Electric Co. Rope drivens by Hill Clutch Co.

River water is available for the surface condenser. The 1400 sq.ft. of cooling surface means $2\frac{1}{3}$ sq.ft. per kilowatt of rating and that at normal load each square foot must condense about 6 lb. of steam per hour.

Five men operate the plant and take care of all the motors in the mill. The annual labor bill is $1770, made up as given in Table 1.

TABLE 1. ANNUAL WAGE OF EMPLOYEES

One chief engineer	$1200
One night engineer	1014
Two firemen	1620
One electrician	936
	$4770

For oil and supplies, including some minor repairs, $250 was expended during the year. This item will, of course, be larger as the plant ages. Records of coal consumption and electrical output are available only for July, August and September. Table 2 gives the totals for each month and the weight of coal per kilowatt hour.

TABLE 2. COAL CONSUMPTION AND ELECTRICAL OUTPUT

	July	August	September
Coal, pounds	486,000	626,680	779,120
Kilowatt-hours	182,560	253,620	253,250
Coal, pound per kilowatt-hours	2.66	2.47	3.08

For the three months the coal, per kilowatt-hour averaged 2.71 lb., costing $2.20 per short ton. During the quarter the 945.9 tons consumed cost $2080.98. In the same period the labor item would amount to $1192.50 and the supplies to $62.50. The total operating cost for the three months would then be

$$\$2080.98 + \$1192.50 + \$62.50 = \$3335.98.$$

Dividing by the total output gives an operating charge per kilowatt-hour of 0.48c. To this a fixed charge of 12 per cent. on the investment—made up by 5 per cent. depreciation, 5 per cent. interest and 2 per cent. insurance and taxes—should be added. For the quarter, 12 per cent. of $55,000 amounts to $1650 and per kilowatt-hour of output to approximately 0.24c. Adding the operating and fixed charges gives a total of $0.72c. per kw.-hr.

For a plant of 600-kw. capacity the cost per unit output is so low as to leave room for reasonable doubt as to the accuracy of the records. It must be remembered, however, that one turbine is running day and night under an economical load and high vacuum, that there is no reserve unit to increase the overhead expense; that few supplies were purchased, and the repairs on a new plant are naturally a minimum. For the service rendered the labor item is also low. It will be of interest to check these figures when operating data over a longer period are available.

Pocket Calculator

The small pocket calculator shown is an ordinary 6-in. logarithmic slide-rule, put into circular form for compactness. It consists of a circular base plate carrying continuous scales on its periphery and lower face; a movable top plate, or rotor, arranged to turn on the hub of the first member and carrying similar scales on its periphery and upper face; a slotted hub nut to keep the rotor in place and adjust the friction thereof and a slider, or runner, with cross-hair and pointers, to be used in conjunction with the first two members.

Circular Pocket Calculator

Shrunk upon the outer circumferential rims of the base plate and movable top plate, and protected by their flanges, are two mechanically divided scales of white, seamless celluloid. Set into sunken panel in the bottom of the base plate and top of the top plate, are flat, hard, white-enamel annular dials, upon a copper diaphragm.

The runner is a bent metal frame carrying a transparent celluloid window. This frame embraces the edges and outer portions of the calculator, and by two pairs of feet, each pair running in a groove, in the top and bottom of the main instrument, is constrained to travel in a circular path: or if the runner be held in a fixed position, the instrument, with all its scales, may be rotated beneath it.

A variety of calculations can be accomplished with this instrument. It is made in several models for different classes of work by Small, Small & Co., Waltham, Mass.

⁂

Modern Lightning Arresters

By Charles C. Raitt

SYNOPSIS—The functions of a lightning arrester, the principal types and their methods of operation.

⁂

The successful lightning arrester must serve the line which it is intended to protect in the following manner:

First, it must immediately relieve the line of any excessive strain whenever called upon to do so.

Second, it must not allow the normal line current to leak to ground, either before discharging or for any appreciable length of time after discharging.

Third, it must recover quickly after discharging and be ready to operate repeatedly.

Fourth, it must be capable of performing these duties without injury to itself.

Multi-Gap

The multi-gap type of arrester represents probably the largest group and is used for the greatest variety of voltages. The telephone arrester shown in Fig. 1 may be considered as the elementary form of this type. The normal telephone current passes into the line binding post *L*, through the fuse *F*, and out the binding post *P*, which is separated from ground by a perforated strip of mica *M*, held between two carbon blocks C and C_1. Lightning discharges break down the short gaps between the carbon blocks and flow to ground rather than take the inductive path through the telephone.

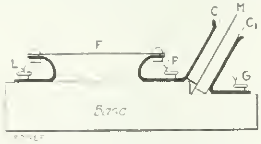


Fig. 1. Telephone Type of Arrester

This arrangement has been improved upon by using a gap inclosed in a metal tube and surrounded by special gases which will give the desired potential to the gap. It is claimed that this type is particularly strong and reliable and gives good cooling surfaces.

Arresters for voltages up to approximately 1000 have several short gaps in series between the line and ground, a common form using a number of knurled cylinders placed on end and so spaced that, when discharging, the arcs form between the knurled surfaces. An arrester of this type is shown in Fig. 2, arranged for 300-volt service. The cylinders are usually made of nonarcing metal, the vapor tending to kill the arc. It is essential that the arc shall be broken as soon as the strain on the line is relieved, otherwise the line current would follow the discharge to ground. The action of the nonarcing metal is in the nature of a rectifying effect, as the vapor from the arc will conduct the current in only one direction. Hence when the current reverses, the vapors have a chance to cool below the arcing temperature before the current again attempts to pass. For this reason arcs caused by a high-voltage discharge tend to die out at the first reversal of current after the discharge has ceased.

Some manufacturers use a resistance in series with the gaps to reduce the dynamic current which flows to ground after the gaps have been bridged by a discharge.

The General Electric Co. recommends a multi-gap arrester with graded-shunt resistances placed as shown diagrammatically in Fig. 3. For line voltages of 5700 to 37,000 and with slight modifications for lower voltages, the action of this arrester is as follows:

Graded-Shunt Resistance

When a high-potential disturbance occurs it takes the path through the high resistance and breaks down the gaps at the lower end of the row, thus passing to ground. If the current thus discharged is heavy, the drop in potential across the resistance may be sufficient to break down the gaps between the high and the medium resistance. In this case, the discharge will take the medium-resistance path. A still heavier current may cause it to jump the next group of gaps and take the low-resistance path. A very extreme case might cause the discharge to desert the resistances entirely and jump the whole line of gaps. As the disturbance subsided and the current died down, the discharge would reverse its program, preferring the shunt resistance to the group of gaps in each step until it was again flowing through the high resistance. Normal line voltage would not be able to maintain an appreciable current through this high resistance and therefore the arc would die out. This principle is superior to that of a resistance in series with the gaps, because in this case the resistances are out of the circuit while a heavy discharge is passing the arrester. Fig. 4 shows a 2200-volt arrester of this type discharging and shunting the current.

A different form of multi-gap arrester is shown in Fig. 5, which is a Westinghouse type, designed for 6600-volt circuits. The gaps occur between the metal pans or caps, mounted on an insulating rod. Below the gaps is a resistance rod, which is in series with the gaps and the ground. The outdoor type has a hood to protect the gaps from rain and snow, when on poles without being boxed.

Circuit-Breaker Type

The circuit-breaker arrester is primarily a multi-gap type, provided with an arrangement for mechanically breaking the path to ground whenever the line current begins to follow the discharge. Fig. 6 shows a 2500-volt Garton-Daniels arrester of this type. The discharge takes the straight-line path, on the right-hand side of the illustration, entering the line binding post at the top, jumping the two upper gaps, passing through the resistance rod in the center and then jumping the two lower gaps to the ground binding post. An inductive shunt circuit is provided by connecting one end of the plunger-magnet coil on the left to the lower end of the resistance rod, the other end of the coil is connected to the upper end of the plunger, and the lower end of the plunger rests on a brass

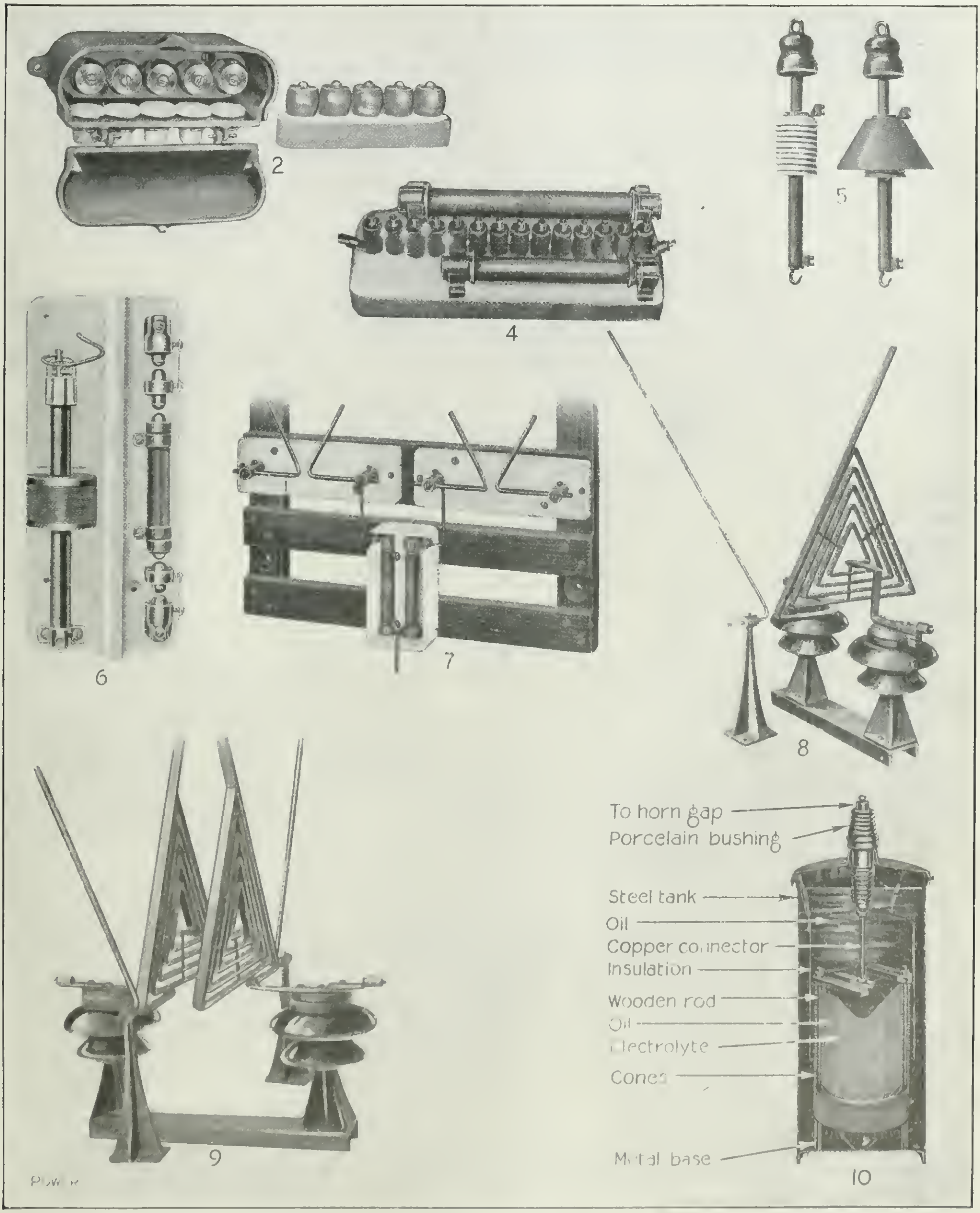


Fig. 2. Multi-Gap Arrester for 300 Volts. Fig. 4. Graded Shunt Arrester for 2200 Volts, Discharging. Fig. 5. Indoor and Outdoor Types. Fig. 6. Garton Daniels Type. Fig. 7. Horn-Gap Type, Mounted for Series Arc Circuit. Fig. 8. Burke Arrester Single Gap. Fig. 9. Burke Arrester Double Type. Fig. 10. Aluminum Cell Arrester

button connected to ground. If the line current continues to flow after the disturbance has subsided it will take the inductive path through the plunger magnet rather than jump the two lower gaps, because of its low frequency. Current flowing in the coil will actuate the magnet and the plunger will open the path to ground. As soon as the arc is broken the current ceases to flow and the plunger falls back by gravity, leaving the arrester ready to operate again. The manufacturers claim for this arrester that the circuit-breaker allows the use of a smaller series resistance and fewer gaps in the path to ground, and also that it provides a positive mechanical break to prevent the line current from following the discharge to ground. It is open, however, to the criticism that any device depending on moving parts for its operation is more easily crippled than one which has none.

HORN GAP

A familiar type of lightning arrester is the horn gap, a simple installation, intended for use on series arc circuits, being shown in Fig. 7. One gap and a series resistance are inserted between each line and the ground. When a discharge has passed to ground the arc rises on the horns due to the rising column of hot gases and thus, reaching a length of gap which cannot be maintained, extinguishes itself. Choke coils are frequently placed in series with the line when horn gaps are used. The high-frequency lightning discharge avoids the choke coil and is more certain to take the path to ground.

Fig. 8 shows the Burke arrester, a combination of horn gap and choke coil in one piece. The horn on the right is one side of a triangular coil wound from strip copper and spaced with fiber blocks. The coil is placed at right angles to the line and in series with it. The ground horn is shown on the left, mounted on a separate holder. A surge or discharge entering from the rear first takes a gradual turn toward the left side and then a sharp turn up. Opposite this sharp turn, where the potential strain is concentrated, is placed the ground horn. Just beyond this point is the choke coil which also provides a magnetic blowout effect which hastens the extinguishing of the arc as it rises on the horns. A single unit of this type will only protect the line in one direction, but it is suitable for use where a line enters a building. A double arrester, providing protection in both directions, is shown in Fig. 9.

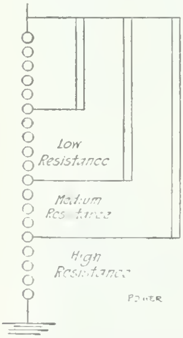


FIG. 3. RESISTANCES IN GRADED-SHUNT TYPE

ELECTROLYTIC TYPE*

The electrolytic lightning arrester is now being used almost exclusively for very high potential circuits and extensively for medium voltages. It seems to be the ideal protection for station equipment, where it can be properly cared for and where there is a concentration of expensive equipment to be protected. This arrester consists of a stack of cone-shaped aluminum plates spaced about 0.3 in. apart, the spaces between the plates being filled with an electrolyte; the whole stack is immersed in a tank of oil. The oil keeps the electrolyte from evaporating and prevents a too rapid rise of temperature during discharge. Fig. 10 shows a section of an aluminum arrester of this type. The principle of the cell is briefly as follows:

The bottom plate is connected to ground, and the top plate to a horn gap, which may be closed when desired to complete the path to ground. After a cell has been installed, it is charged by closing the horn gap through a resistance. A current then passes to ground through the electrolyte and causes a film of aluminum hydroxide to form on the aluminum plates. As the film grows thicker it offers more and more resistance to the current until finally only a slight current will pass. The cell is then ready for use. The film which has been formed has a critical voltage and when that voltage is exceeded the cell will discharge large currents for short periods without harm to itself. The horn gap is set large enough to prevent a leakage current from passing constantly through the cell, but not large enough to interfere with the operation of the arrester. This type of arrester is very effective in relieving the line of surges as well as from lightning discharges. The cell must be charged about once a day because the film dissolves gradually when the cell is idle.

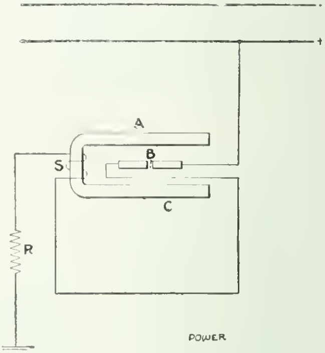


FIG. 11. MAGNETIC BLOWOUT TYPE FOR DIRECT CURRENT

When used on a three-phase circuit with grounded neutral, three cells may be used and connected to a common ground; an arrangement which gives two cells between each two phases. In case of a fallen line there will be a dead short-circuit on one phase, the circuit-breakers will open that phase and there will be no danger of destroying the cell. When used with a three-phase circuit without the grounded neutral it is necessary to provide a fourth cell between the common ground wire of the other three cells and the actual ground. When this system is used and a line falls there will still be two cells between each two phases. This arrangement is also used with other single-pole arresters on three-phase lines.

ARRESTERS FOR DIRECT-CURRENT CIRCUITS

An arrester which is commonly used in railway work and is well adapted to low-voltage, direct-current apparatus, is shown in Fig. 11. It consists of a spark gap B placed between the two poles of a magnet A-C. A discharge in passing to ground jumps the gap, passes through the coil S and the resistance R to ground. When the line current attempts to follow the discharge across the arc it produces a magnetic field in the coil S, which flows from A to C, and draws the arc out of its course, causing it to become so long as to cool and break. This is familiarly known as the magnetic-blowout type of arrester.

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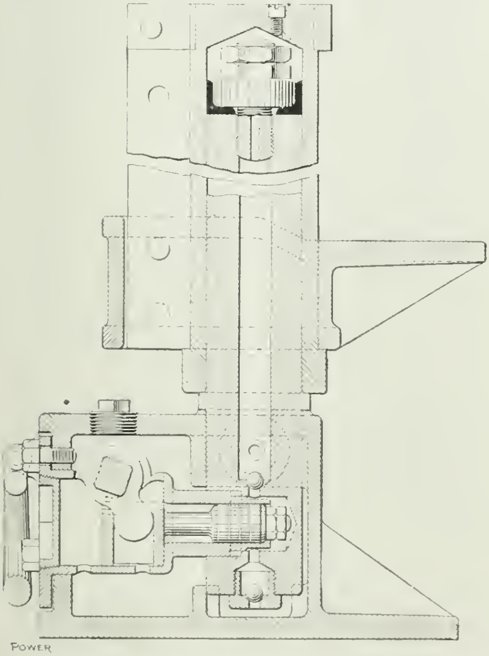
*For a more detailed description of this type see "Power," Sept. 9, 1913.

Emergency Hydraulic Jack

A type of hydraulic jack embodying new features is illustrated herewith. The claw can be moved vertically and adjusted to a convenient height. With the cylinder, the claw can be swung in a circle without changing the position of the jack body or of the pump lever. The cylinder is the moving part of the jack instead of the ram, which allows the pump mechanism to stay in a fixed vertical position.

The piston is packed with leather rings; ball valves are used and there are ample oil passages. The oil, besides acting as a lubricant, prevents rusting of the working parts and the possibility of freezing, and it has no detrimental effect on the packing. The oil pressure is released by a key operating a small needle valve.



Section through Hydraulic Jack

The 18-in. operating lever is curved. The socket has a hole in each of its four sides to allow convenient operation from various positions.

This jack, manufactured by the Watson-Stillman Co., New York City, is built in 5- and 10-ton sizes, with a ram stroke of 10 in., and is guaranteed to withstand a 50 per cent. overload.

*

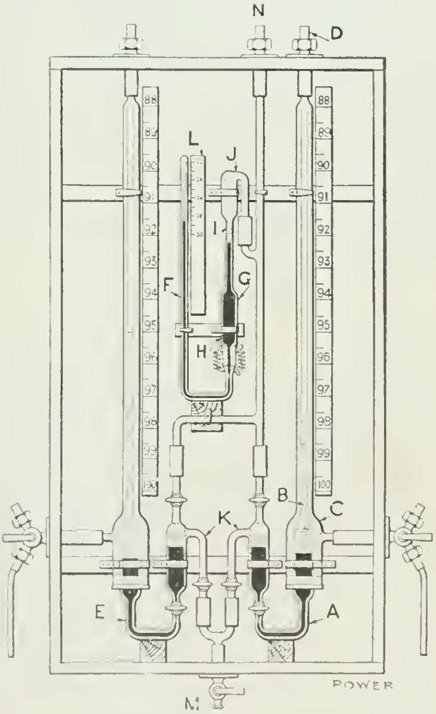
Damage to Feed-Water Heaters—If the float valve at the feed-water heater sticks, it should not be raised by the engineer in order to admit water which is at city pressure. This pressure may cause the heater to burst through the failure of the overflow trap to quickly relieve it. Occasionally a heater is damaged by an engineer who, in an attempt to heat the water in the heater, will so manipulate a trap that the steam in the high pressure drips will blow directly through it and into the heater.

New Condenser Gage

A new gage for use with steam condensers, the Scanes vacuum efficiency and absolute pressure gage, has recently been developed. The device is designed to show if the condenser is dirty; if too little cooling water is being used; if there is an excess of air in the system; if the cooling water is too hot; if power is being wasted by pumping too much cooling water, or whether the air pump is in good condition. The gage is for constant use with the condenser, and not only denotes the true vacuum and whether it is varying, but also indicates the causes of the changes.

When the gage is used with a surface condenser it reads the absolute pressure, or vacuum corrected to a 30-in. barometer; the vacuum efficiency, i.e., the percentage of the theoretical vacuum due to the condensed steam temperature which is being maintained in the condenser, and also the condenser efficiency, or the percentage of the theoretical vacuum due to the cooling-water discharge temperature.

When used with a jet condenser, the second and third readings are the same.



Gage for Surface Condenser

The glass U-tube *A* (see illustration) is sealed at one end, exhausted of air and then filled with colored water *B*, which is heated to the temperature of the condensed steam by a small jet of the latter, drawn through the outer tube *C* through the connection *D* to some convenient point of vacuum. The water in the inner tube *A* then takes such a position that the vapor pressure in the tube and the column of water in that leg will bal ance the vacuum in the condenser and the column of water in the other leg; the difference of level of the colored water in the two legs is a measure of the vacuum efficiency of the condenser, as the colored water is at the temperature of the condensed steam.

The pipe N is connected to the vacuum to be tested. The left U-tube E in a similar manner reads the condenser efficiency, a small stream of the discharge cooling water being passed through the outer tube. The mercury in the bottom of the U-tube is to prevent air passing into the sealed side.

For a jet condenser but one U-tube is used.

The mercury U-tube F is an improved absolute pressure gage for indicating the vacuum in the condenser, corrected to a 30-in. barometer. No chemicals are used and water condensing on the mercury does not affect the reading. The left side of the U-tube is sealed and exhausted to as perfect a vacuum as is possible the tube is filled with mercury and the other end is closed by a thin rubber sack, inclosed in a glass bulb and is filled with mercury.

The pressure in the condenser is transmitted to the mercury in the bulb G, and then through the rubber sack H to the mercury in the sealed leg. The difference of level of the mercury in the two legs is a measure of the vacuum in the condenser. The rubber sack is only partially filled with mercury and is not in tension, and does not affect the reading. The bulb G is continued into a narrow tube, which is again enlarged at I to form a second bulb J, which is filled with water to the overflow K; the scale L is corrected for the weight of water on the mercury, and any further water which condenses in J, overflows, and can be blown back into the condenser by opening the cock M.

Examples of the use of the gage are as follows: A vacuum in F of 28 in., with a vacuum efficiency of 98.5 per cent., and a condenser efficiency of 98 per cent., shows that the efficiencies are normal, and the vacuum is as good as may be expected without more cooling water. If the vacuum drops to 27 in., the efficiencies are as before, but either more water is needed, the inlet temperature has gone up, or the condenser is overloaded. If the vacuum is 27 in., with a vacuum efficiency of 98.6 per cent. and a condenser efficiency of 94 per cent., the condenser needs cleaning. In another case, with a vacuum of 27 in., and both efficiencies worse, there is probably an air leakage; alternatively, the air pump is in bad condition, or in the case of a rotary air pump the seal water is too hot.

As a further example, suppose the engineer is not satisfied with a vacuum of 28 in., and increases the circulating-water quantity, without result, he will probably see that although the vacuum is still 28 in., the efficiencies have fallen off. This would show that the air pump is not capable of more than 28 in., with the existing air leakage, and he must either reduce this or increase the capacity of his air pump. If, however, only the condenser efficiency had fallen (with the condenser clean), and the vacuum efficiency had remained at 98.5 per cent., it would prove that the size of the condenser would not allow of a higher vacuum.

* *

Equipment and Methods in Largest Refrigeration System--III

By Charles H. Bromley

SYNOPSIS—Further description of the 1000-ton ammonia compressor of the Quincy Market Cold Storage & Warehouse Co., Boston. A governor driven through automobile transmission gears, with other features, allows flexible adjustment. A synchronous motor-driven tachometer indicates the speed, and a crank index helps the operator in starting and stopping the compressor. A quick-closing throttle with electric and steam control is also a feature. Lubrication system for the compressor which handles two widely different suction pressures in the same cylinders.

*

An Interesting Governor

Wide range in speed is essential in ammonia-compressor practice, and is especially so here owing to the nature of the service. The governor has been designed to make the machine as flexible in speed as possible and to allow the attendant to make adjustments quickly and conveniently.

The governor proper, Fig. 4, is of the usual Rice-Sargent design, but has some most interesting additional features. It is driven by a layshaft from the main shaft through gear transmission designed after the transmission in an automobile. Six different speeds may be obtained by shifting these gears by means of the knob and recesses shown.

After the shift has been made, the gears may be locked by swinging over the arm A. A change of ten revolutions may be had for each shift in the gear box, and as six shifts are possible, this gives sixty revolutions. For variations of less than ten revolutions, the weight on the quadrant is used. This quadrant has thirty-seven notches, each notch giving a variation of one-third revolution. This, you see, gives 37 × 3.333 = 12.3 revolutions, which enables the operator to carry the speed beyond the ten possible by shifting gears. With this governor then, the speed may be varied by as low as one-third revolution between thirteen and seventy-five.

Synchronous Motor-Driven Tachometer

For accuracy in speed indication, Mr. Fairbanks, the chief engineer for the company, designed a tachometer driven by a synchronous motor; a small 25-cycle generator, belt-driven from the governor layshaft, supplies the current. This tachometer is very sensitive. Next to it on the gage-board is a combined indicating and recording steam-pressure gage, the pipe of which is on the compressor side of the throttle. As the pointer of the gage rises and falls as cutoff causes the pressure in the steam line to momentarily fluctuate, the movement of the tachometer pointer is seen to synchronize with it. The gage boards and the steam-control valves are shown in Fig. 5.

Formerly, the governor was lubricated by oil which dropped from the cup at the top of the casing. Sometimes the cup outlet or the tube leading from it would become obstructed. The oiler would not notice this condition for some time because the cup showed plenty of oil. To make a full or partly filled cup an indication of trouble proved good practice. The oil now goes through the cup on its way to the governor parts, but when the cup fills, it shows that the connections between it and the parts to be lubricated are obstructed.

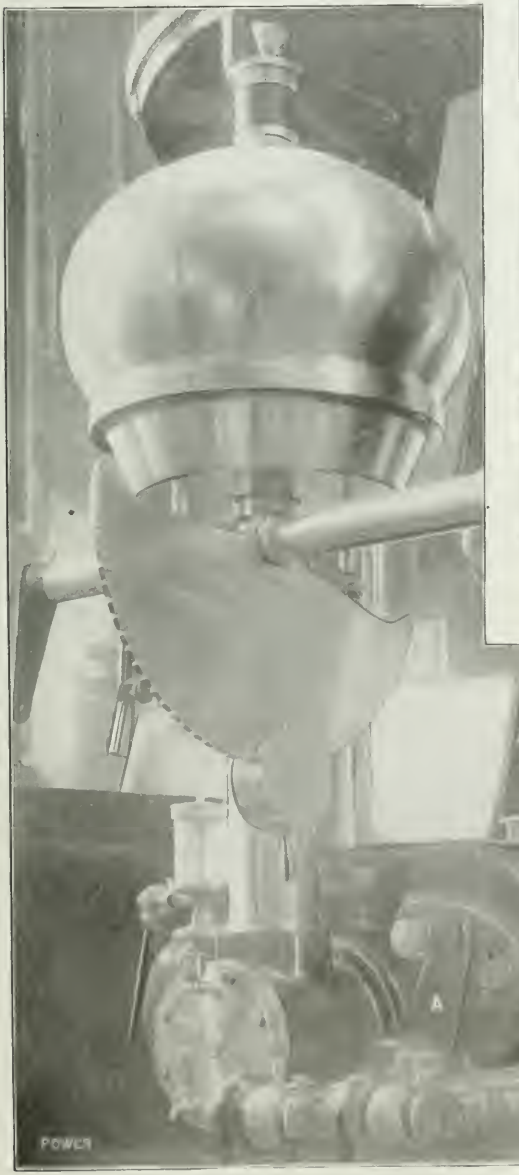


Fig. 4. Governor for the 1000 Ton Compressor: Driven through Automobile Speed Transmission Giving Unusually Wide Range in Speed

Quick-Closing Throttle

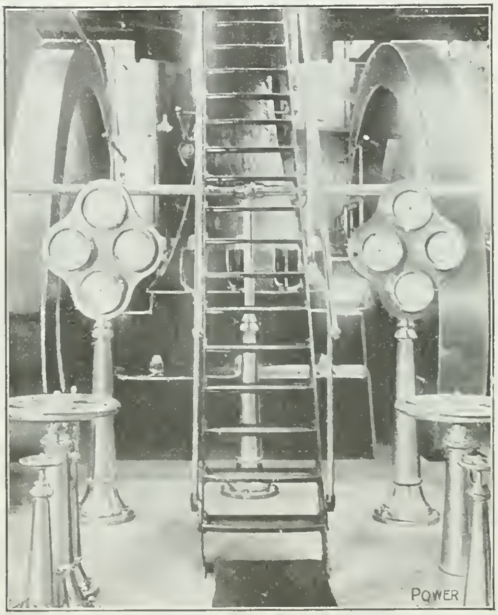


Fig. 5. Gage Boards and Control Valves for the 1000-Ton Machine

Serious damage to compressors has occurred, because before the attendant could close the throttle it was too late to prevent accident. To avoid such conditions the 1000-ton machine has an electrically operated, quick-closing throttle. The quick-closing valve is at the left of the throttle, as shown in Fig. 6 and the bypass pedestal is at the immediate right, giving all steam control within an arm's length. The quick-closing mechanism consists of a solenoid-operated, spring-loaded pilot valve furnishing steam pressure to a balanced throttle. Provisions have been made to operate the solenoid by a push button on the watch engineer's desk.

Each valve on both steam cylinders may be operated separately by throwing out a clutch by simply turning a knurled knob provided for each valve, and pulling it open or shut with a bar. The steam valves are triple ported to give maximum opening with minimum movement. The valve gear is shown in Fig. 7.

The jacket of the high-pressure steam cylinder gets superheated steam (150 lb., 125 deg. F. superheat, total 491 deg. F.) and this jacket water and steam together with all high-pressure drips go to a regenerator, the re-evaporated water passing into the low-pressure cylinder. The clearance volume in the steam cylinders of this machine is quite low, being but 1½ per cent. Metallic packing is used in the steam end and all joints, such as those at the cylinder heads, valve bonnets, etc., are metal to metal, no gaskets whatever being used.

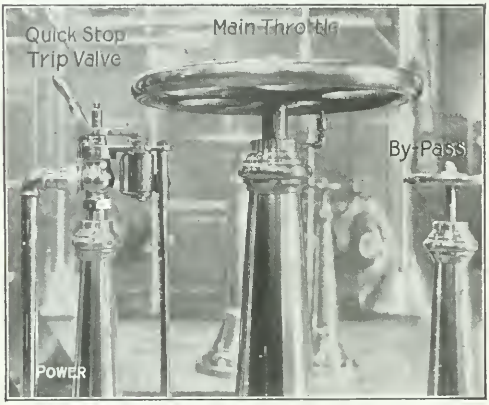


Fig. 6. Relative Location of Throttle, By-Pass and Quick-Stop Trip Valves

Lubrication of the 1000-Ton Machine

Steam-cylinder lubrication is done with a noncompounded mineral oil without graphite. Instead of trying to obtain atomization of oil as it enters the cylinder, the object is to put the oil in cold and depend upon the piston to wipe it over the cylinder wall. Oil pumps are provided for hand lubrication for starting and for emergencies, the oil reaching the cylinder walls in five different places for each cylinder. Fig. 8 shows one of these cups mounted on the head of the low-pressure cylinder. The cup for the centrifugal oiler for one of the crankpins is shown in Fig. 9. The centrifugal oilers (provided on all compressors and brine pumps) have a lip on the inside of the receiving shell to keep the oil from spilling out by gravity, as it will with most types of "banjo" oilers when the centrifugal force is reduced below a given amount. One of the large oil cups as used on the fill-pieces between the ammonia cylinders and A-frames is shown in Fig. 10; these oilers supply the wristpins and guides. Emergency lubricators as used on the steam end of the 800-ton machine are shown in Fig. 11. Pipes run to the top and bottom of the cylinder and the indicator connections are used to get oil to the side; Fig. 12 shows how the low-pressure valve rods are lubricated. The present forced-feed lubrication system will be displaced by a gravity-type system.

The three ammonia cylinders are each 30x50 in., the volume of each, neglecting piston clearance, which is only 10-thousandths of an inch, being 3534 cu.in. and the displacement of the machine at 75 r.p.m. (neglecting clearance) is 920 cu.ft. per min. Each ammonia head contains fourteen valves, and an extra head is kept on a hand truck near the machine to be lifted by the crane and put on in a hurry when emergency demands; this head is shown in Fig. 12a.

Two Suction Pressures Handled

The back pressures for the warehouse and street systems are different, but are handled by the same compressor. This is accomplished by taking the low-pressure gas through the suction valves for 48 in. of the stroke and then admitting the high-pressure gas from the second system through ports uncovered by the piston, the high-pressure compressing the low-pressure to a volume in direct ratio to the pressures and at a lower temperature than would be normal with the high-pressure gas alone, thus greatly increasing the capacity of the compressor.

All metal surfaces of the ammonia end of the compressor with which jacket water is in contact are painted heavily with boat bronze, a paint made of spar varnish and bronze powder, to resist the corrosive action of the harbor water, which contains free chlorine from the sewage. Also it contains magnesium chloride, and experience shows that when salt water is heated the magnesium chloride in solution tends to dissociate into magnesium oxide and hydrochloric acid on the application of heat, the hydrochloric acid, of course, being highly corrosive. This boat bronze proves to be a good corrosion-resisting material for such service. Like other paints for the same or similar purposes, it must be well brushed into corners and recesses and for this reason it pays the one in charge to closely inspect the work. The corners of nuts especially should be well coated, otherwise they will waste away and be crushed and sheared off when a wrench is applied, as is often necessary when stopping ammonia leaks when tightening a plug in the ammonia head.

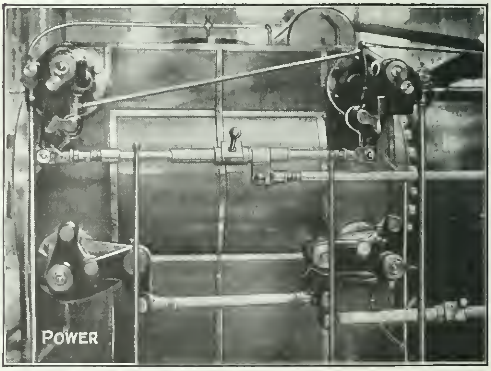
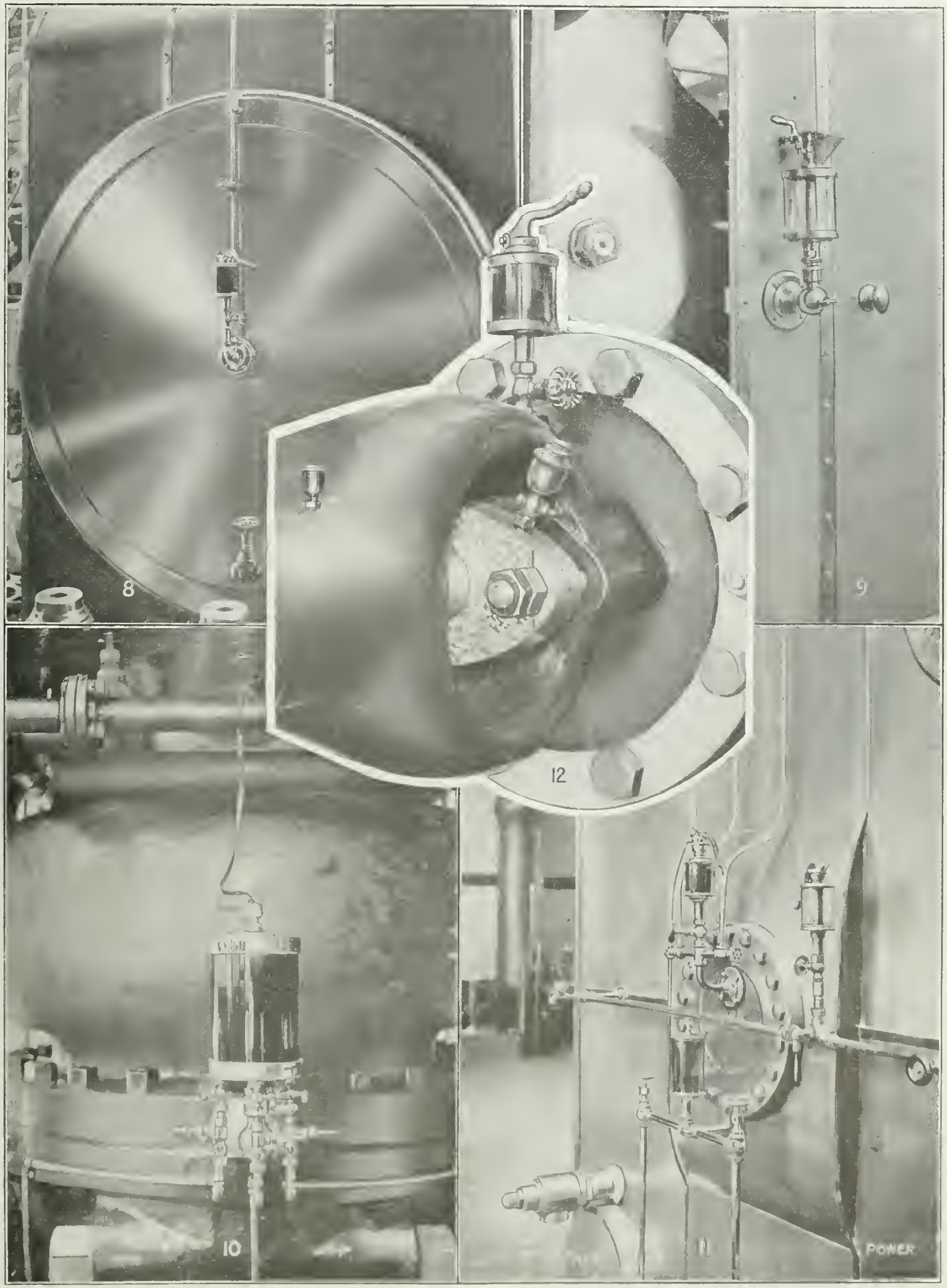


Fig. 7. Valve Gear of the Low-Pressure Cylinder

The water for each cylinder enters the jacket through a 2-in. pipe, having four openings below the end and an umbrella-shaped hood over the top to deflect the water downward, as shown in Fig. 13. This gives a better cooling effect than if the water were allowed to discharge from the end of the pipe direct, because it stratifies the water.



Lubrication for the 1000-Ton Ammonia Compressor

Fig. 8. Oil pump on head of low-pressure cylinder. Fig. 9. Oil cup for one of the large crankpins. Fig. 10. Oiler for the vertical guides and the wristpins. Fig 11. Oil pumps on indicator pipes of the 100-ton machine Fig 12. How the valve stems for the big compressor are lubricated

The high speed (75 r.p.m.) for which the compressor is intended calls for a valve of a design that will allow it to open and close rapidly, be tight and not wear

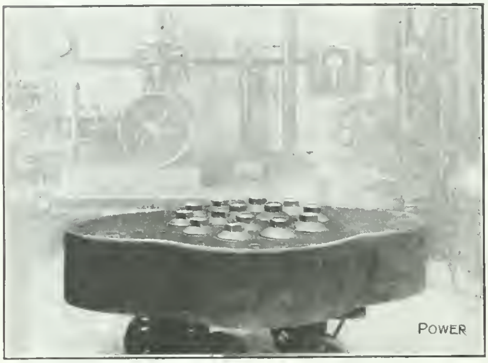


Fig. 12A. One of the Ammonia Heads of the 1000-Ton Machine

quickly. Fig. 14 shows one of the suction valves, and Fig. 15 one of the discharge valves. These illustrations are almost exact reproductions of the assembly drawings sent to the builders and show and state the details so clearly that no further description is necessary.

It should be understood that "1000 tons," as applied to the compressor, is really only a name, for at 75 r.p.m., the normal speed, the machine develops 1250 tons.

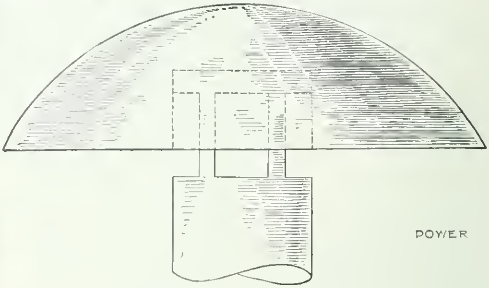


Fig. 13. One of the Umbrella Deflectors for the Compressor Jacket Water

The machine has been admired by many visiting designers and builders and all commend it most highly, but many remark that to build such machines is commercially prohibitive because of its cost. The machine complete cost $75,000, and as its rated capacity at 75

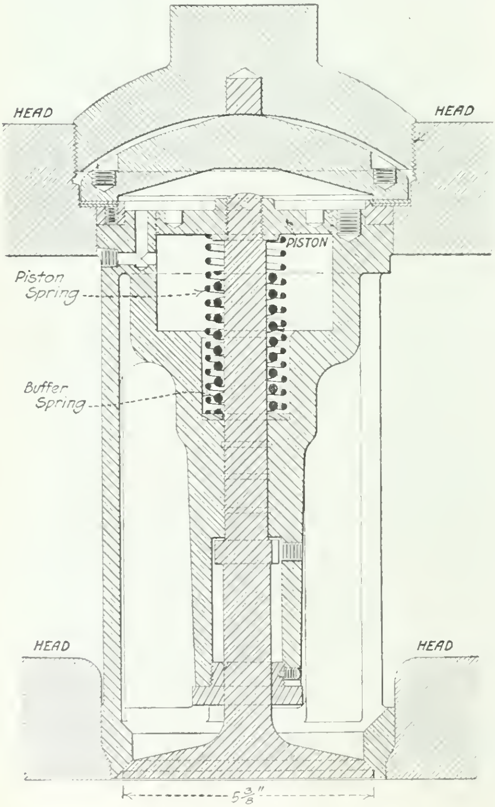


Fig. 14. Suction Valve of the 1000-Ton Compressor

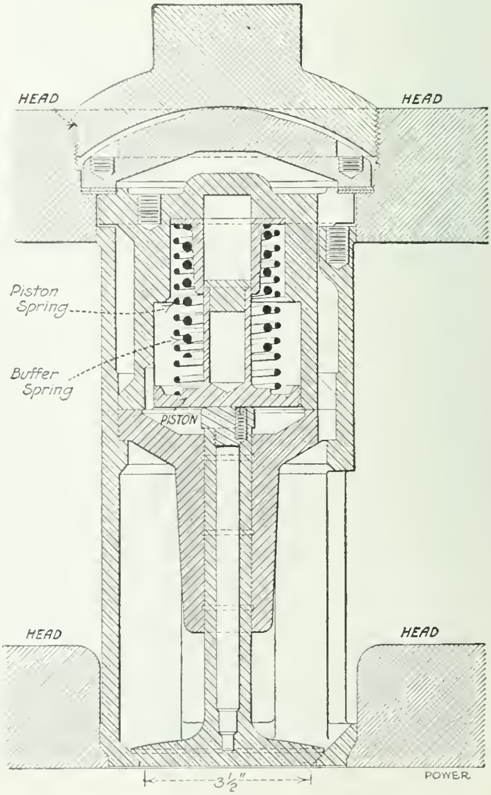


Fig. 15. Discharge Valve for the 1000-Ton Compressor

r.p.m. is 1250 tons, the price per ton capacity is $60. The contractor was in no way responsible for the machine. If, when the various parts arrived, the measurements were as specified though in error enough to make trouble in assembling on the foundation, the responsibility was entirely up to the designer. The same was true for the performance of the machine.

Figs. 15a and 15b show diagrams from the ammonia end of the 1000-ton compressor. The reader will recollect that this machine receives gas at one pressure from the warehouse system, and at another from the street system. The first figure shows a diagram taken while gas at only one pressure was being handled. The suction lines follow the atmospheric lines in both diagrams. Notice that there is no perceptible reëxpansion, the valve action being exceptionally good during all events of the cycle. Fig. 15b was taken while the machine was receiving gases at two different pressures, the high-pressure gas entering through a port in the piston after it had traveled 48 in. of the 50-in. stroke. Referring to the suction end, it will be seen that the port area in the piston is sufficient to allow the high-pressure gas to get in before the end of the stroke is reached. The diagram also shows that the piston port is covered before compression can force the gas back into the port. The advantage of using two suction pressures is, of course, to increase the capacity of the machine. How much it increases it is apparent from the diagrams, for the first diagram, where one pressure is used, has considerably more area than the second where two gases are admitted.

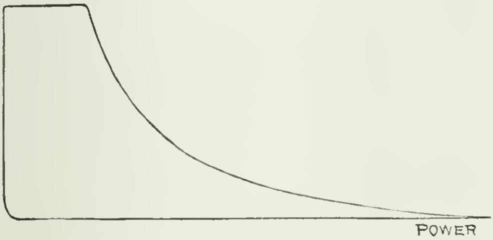


FIG. 15A. AMMONIA DIAGRAM, ONE SUCTION PRESSURE

Discharge pressure, 123 lb.; suction pressure, atmospheric; scale of spring, 80 lb.; 30 r.p.m.; cylinder, 30x50 in.

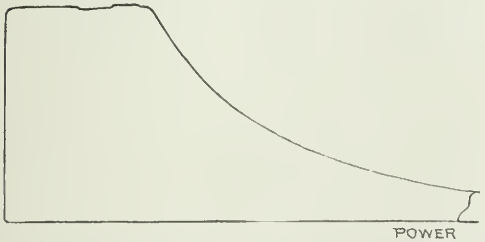


FIG. 15B. AMMONIA DIAGRAM, TWO SUCTION PRESSURES

Discharge pressure, 123 lb.; low suction pressure, atmospheric; high suction pressure, 17 lb.; scale of spring, 80 lb.; 30 r.p.m.; cylinder, 30x50 in.

*

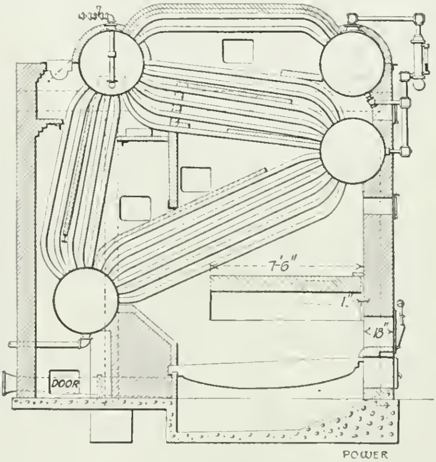
To Find the Area of an Ellipse—The area of an ellipse is equal to 0.7854 times the product of the axes of the ellipse. Example: The major axis is 15 in. and the minor axis 10 in. Applying the rule,

$$15 \times 10 \times 0.7854 = 117.81 \text{ sq.in.} \quad \text{Ans.}$$

Improved Badenhausen Water-Tube Boiler

The original Badenhausen water-tube boiler, described in the Sept. 22, 1908, issue, consisted of four drums, the lower or mud drum being connected by tubes to the rear and lower front drum. The upper front drum was connected to the top rear and bottom front drum by banks of tubes.

The present design of this boiler retains the four drums in practically the same relative positions, but the arrangement of tubes between them is different. The lower front water drum and the rear steam and water drum are connected by tubes to form the course of circulation for the water. The upper front steam drum is connected through the water column opening to the lower front drum.



SECTIONAL VIEW OF BADENHAUSEN WATER-TUBE BOILER

The boiler is supported by heavy steel I-beam framing. The water drum is suspended from heavy bolts secured to these I-beams, and the mud drum is suspended from the tubes which connect to the rear steam and front water drums. This arrangement gives flexibility to the boiler, as but one drum is stationary, and although variations of temperature occur in the boiler, the liability of the tubes being distorted or torn out from the drums is remote. The front steam drum is placed upon a heavy steel support and connected by steam tubes to the rear drum and by water connections to the front water drum.

All drums are designed and built according to the Massachusetts and Ohio boiler laws, with double butt-strapped and double-riveted joints.

The drum heads are made of extra-heavy steel with manholes pressed in. The tubes enter the drums radially and are expanded and flared. The absence of short tubes with the middle lower than their outer ends does away with all pockets for dirt or scale.

The arrangement of the tiling and baffling is shown in the illustration, a hand-fired furnace. No special baffles are needed and standard tile only is used. An examination of the baffling will indicate how the hot gases must pass all of the tube-heating surface.

The boiler is cleaned internally by removing four handhole covers and inserting a tube cleaner into the tubes. The outside of the tubes is cleaned by inserting steam lances from the boiler front. The necessary repairs are facilitated by the tubes being spaced alternately wide and narrow, permitting the replacing of any tube without disturbing any other tube; no baffles need be disturbed. Owing to the cycle of circulation in the boiler, impurities are finally thrown into the large mud drum, when they may then be blown off. As the feed water enters the top rear drum and passes down the rear outer tubes, the scale will be found in these tubes and also in the mud drum.

The main characteristics of this boiler are that the area of the tube entering the drums and leaving them is practically the same, thus permitting unrestricted circulation; the large disengaging surface of the boiler, which is the total area of the tubes discharging into the rear drum; and the fact that the steam in passing through the steam tubes is dried and slightly superheated.

This boiler is manufactured by the Badenhausen Co., 1429 Chestnut St., Philadelphia, Penn.

⁂

Thick Boiler Plates

By S. F. Jeter

The proper thickness of fire plates for horizontal tubular boilers is a mooted question. In practice five-eighths of an inch seems to be about the maximum, owing to the trouble at the girth seams with plates of even this thickness.

There is no conclusive evidence that plates of five-eighths of an inch and over are more likely to give trouble in the *solid part* under the same operating conditions than thinner plates, and they have been used with apparent success so far as the solid part of the plate is concerned. Since there is a tendency in proposed boiler rules and laws to limit the maximum *tensile strength* for the shell plates, the question arises as to what the limit in thickness may be. The first trouble with thick sheets appears at the girth seams where the plate is doubled.

There is need of experimental data to show how the transmission of heat occurs at this point. The belief at present is that the principal resistance met with is at the two surfaces, therefore there can be but little heat transmitted through the outer lap of the joint except where the two plates are held in intimate contact by the rivet.

It is a fact that well fitted seams show less tendency to fire-crack and to give other trouble than those not so well fitted, but this does not prove the case conclusively. For example, Fig. 1 represents a section of a poorly fitted seam before the edge of the outer plate was calked. While poor fitting would tend to prevent the proper transmission of heat through such a joint, the plate along the calking edge would also be under a severe strain when the rivets pull the two courses together. Both conditions would tend to cause fire-cracks where local heating occurred.

The stress on the edge of the sheet by the use of a drift pin to bring holes in line would be almost certain to produce fire-cracks.

Punching rivet holes, drifting, bevel-shearing and the probability of the imperfect fitting of the courses all have considerably greater effect on thick than thin plates. These are some of the reasons why trouble at the girth seams may be experienced, which is not alone caused by poor heat transmission on account of the thickness of the plates. Attempts have been made to avoid the foregoing trouble by reducing the thickness of the outer lapping plate at the seam, Fig. 2. I question the advisability of the method shown in the illustration because it produces a local weakness at a point where considerable strain due to expansion and contraction occurs, and it may be found that the plate has a tendency to crack at some point between *A* and *B*.

There is reason for believing that the heat is largely transmitted lengthwise of the shell, indicated by the arrows in Fig. 3. This is the reason for restricting the length of lap of such joints.

When the Massachusetts Rules first went into effect, it was specified that all riveted joints should have the distance from the center of the rivet hole to the edge of the plate not less than one and one-half times the diameter of the rivet hole, but this rule had to be changed and it now applies only to longitudinal seams, because that amount of lap on a fire seam was not satisfactory as was proved by experience.

In case of trouble at a girth seam the boiler maker chips the edge of the plate, primarily to secure a new edge of metal to calk, but it also improves the conditions by shortening the lap and placing the new calking edge closer to point *C*, Fig. 3, and therefore it is not so apt to become overheated. Frequently, the result is that seams that could not be kept tight as first constructed remain tight after this treatment. A microscopic examination of the edge of the plate of a girth seam exposed to the fire was made by an engineer connected with a prominent boiler company. The indications were that the part of the outer lapping plate shown shaded (Fig. 4), was exposed for a long time to temperatures high enough to cause structural changes. In short, it was burned, while the metal elsewhere was in good condition. This would indicate that the transmission of the heat was lengthwise of the shell, as previously stated.

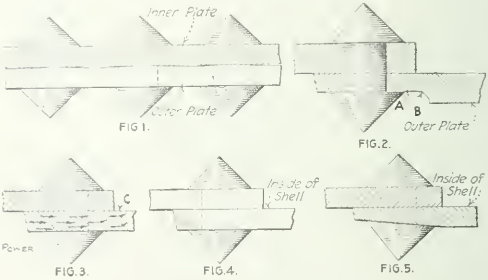


FIG 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5.

Joints for Thick Plates

From the foregoing, I believe that thick plates could be used by constructing the joint in the following manner: First, by using rivets with large heads, because all of the surface covered by the rivet heads is protected from the heat, which is conducted through the body of the rivet to the water inside of the boiler. Second, by having the courses well fitted together so as to get the maximum benefit from the contact between the plates. Third, by having the calking edges of the plates planed instead of bevel-sheared. Fourth, by reducing the thickness of the edge of the overlapping plate (Fig. 5), so that the maximum lengthwise heat transmission may be obtained. This gradual reduction does not weaken the plate locally, as in Fig. 2, but it certainly improves the longitudinal transmission of the heat.

There may be some objection to driving the outer rivet head on a slanting surface, but since the original head of the rivet would be in contact there should be no trouble experienced if a die of the proper form is used and the rivet is held in the right position in the ram of the riveter.

* * *

Headroom for Smokeless Settings[*]

By Osborn Monnett[†]

The accompanying table is intended as a summary to compactly give the minimum headroom requirements for good performance for the combinations of boilers and furnaces found in use in Chicago. The "headrooms" were taken from actual installations, which are running satisfactorily. So far as capacity is concerned, there is no reason why any of the combinations listed could not run with a clean stack, considerably above rating, provided the draft was sufficient and proper methods of operation were used. While not intended for high ratings or for special conditions, the settings may be taken as standard for ordinary commercial work in the average industrial plant.

Horizontal Return-Tubular Boilers

For boilers of this type, department furnaces Nos. 6, 7 and 8 are quoted from shell to dead plate. This dimension was given to insure a satisfactory bridge-wall and to obtain proper area. When the ashpit is low it is assumed that the floor of the combustion chamber will be lowered sufficiently to get the proper areas through the furnace, as set forth in previous articles on such settings.

For underfeed stokers the dimension from shell to dead plate on horizontal return-tubular boilers is given, leaving the depth of ashpit to the individual characteristics of the stoker used. Of course, with underfeeds the combustion chamber need not be lowered as in the case of hand-fired furnaces.

With the exceptions noted, all quotations on horizontal return-tubular boilers are from shell to floor line, as the equipment consists of proprietary furnaces, in which the manufacturer can suit his own ideas as to the location of the grate.

The heights given for side-feed furnaces are for standard ratios between grate and heating surface. For freak settings using wide boilers or for ratios of grate to heating surface higher than standard, the headroom must be increased to correspond with the greater spring of the arch necessitated by the wider span. With this style of stoker the clinker bar should be located at or slightly above the floor line.

Taylor and Westinghouse underfeeds are not quoted on horizontal return-tubular boilers as they are not generally installed under units of small capacity. A 72-in. by 18-ft. boiler would probably be the smallest unit which these stokers might serve. In this case a headroom of 84 in. would be recommended.

Water-Tube Boilers

With water-tube boilers no distinction has been made between boilers having 1-in. pitch to the foot and those having 1½-in. pitch, as it has been found that the difference in practice so far as furnace design is concerned is negligible. Boilers with 3¼-in. pitch affect the furnace design sufficiently to warrant a separate column. Higher headroom is required principally to give the proper cross-sectional area in the combustion chamber so that the heat will not be "bottled" in the furnace, and to insure long flame travel by raising the heating surface far enough away from the grate, especially at the inner end near the bridge-wall.

HEADROOM REQUIREMENTS FOR SMOKELESS SETTINGS
(All Dimensions in Inches)

	Furnaces	Horizontal Return Tubular				Water Tube				Continental or Scotch Marine
		54	60	66	72	Hor. Baff. 1-1½″ Pitch	Vert. Baff. 1-1½″ Pitch	Hor. Baff. 3¼″ Pitch	Vert. Baff. 3¼″ Pitch	
		Shell to dead plate				Front header to floor				
Hand Fired	No. 6	32	34	34	36	72	*	78	*	**
	No. 7	36	40	40	42	†	†	†	†	**
	No. 8	32	34	34	36	72	*	78	*	**
		Shell to floor								
	Down draft	60	60	60	60	72	*	78	*	*
	McMillan	52	54	60	60	72	*	78	*	**
	Twin fire	58	60	62	64	72	*	78	*	*
	Semi. ext., refuse burning	††	††	††	††	84	*	90	*	*
Gravity Feed	Burke	48	48	50	54	60	*	66	*	Full extension
	McMillan	48	48	50	54	60	*	66	*	Full extension
	Chain grate	72	72	78	78	84	114	96	120	**
Front Feed	Moore	48	54	60	60	72	102	78	108	**
	Roney	60	60	60	72	84	108	90	120	**
	20th Cent.	54	60	66	72	84	108	90	120	**
Side Feed‡	Detroit	66	72	78	84	90	*	96	*	Full extension
	Model	66	72	78	84	90	*	96	*	Full extension
	McKenzie	66	70	70	70	90	*	96	*	Full extension
	Murphy	66	72	78	84	90	*	96	*	Full extension
		Shell to Dead Plate								
Under Feed	American	42	42	42	42	78	96	84	102	**
	Jones	36	38	40	42	78	96	84	102	Min. diam. of furnace 36 in.
	Taylor	**	**	**	**	84	102	90	108	**
	Westinghouse	**	**	**	**	84	102	90	108	**

* Combinations not recommended as smokeless settings.
** Combinations not ordinarily met with in practice.
†Not adapted to water-tube boilers.
†† Applied only to water-tube boilers: No. 8 better for H.R.T. boilers.
‡ Exceptionally wide settings will need more head room to take care of extra spring of arch.

Unsatisfactory Combinations

There have been some combinations of vertically baffled water-tube boilers and furnaces which have not resulted in smokeless settings. The dampening action of the tubes combined with the short flame travel results in the production of too much smoke for congested communities. These combinations are noted in the table.

Vertical Boilers

It has been found practically impossible to formulate a set of standard conditions for vertical boilers. In general, all furnaces in connection with these boilers should be set full extension, giving the maximum flame travel which the floor space will permit in any given situation. The exact amount of extension depends upon so many variable conditions that each case must have individual study before quotations can be made. With mechanical stokers serving vertical boilers it is not difficult to get a smokeless setting, but with hand-fired furnaces the extension required to get proper mixing action frequently results in a cumbersome combination.

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[*] Copyright, 1914, by Osborn Monnett.
[†] Smoke Inspector, City of Chicago.

CONTINENTAL BOILERS

With this type of boiler the solution is a full extension, gravity-feed furnace, or an underfeed stoker installed directly inside the corrugated flue. The application of furnaces to this type of boiler is limited to a few types as noted in the table.

⁂

Superheat for Corliss Engines

By E. R. PEARCE

The steam consumption of all types of engines will be improved by a moderate degree of superheat. The chief point, however, is the design of the cylinder, for in some, appreciable distortion takes place with ordinary steam temperature only, so that trouble may be caused by the addition of even 80 to 100 deg. of superheat.

In the average Corliss engine, with tight valves and pistons and the cylinder not steam jacketed, little is to be gained in having more than 80 deg. of superheat at the inlet valves. That is, the superheat should be just high enough to insure dry steam at the cutoff.

Superheat, besides reducing the steam consumption, will allow of considerably less cylinder oil being used, providing, of course, that an oil having suitable properties be used. This reduction in oil is probably due to the removal of moisture in the steam, thereby preventing the oil from being washed off.

In ordinary compound and triple-expansion engines no effects of the superheat will be found past the high-pressure cylinder, even in short-stroke, high-speed types, unless they have a late cutoff in the high-pressure cylinder, use high superheat (150 to 175 deg.), and are fully loaded; in which case a slight amount of superheat will be found in the high-pressure element. Before applying superheat to a Corliss engine which has been running for a few years on saturated steam, it is advisable to remove all the valves and take off the sharp edges from the ports as well as the valves. This will prevent the scraping off of the oil, which naturally will be a little thinner at the higher temperature. Scraping off of the oil is the cause of grooving in many Corliss engine valves.

It is not advisable to employ more than 50 deg. superheat with slide-valve engines running under more than 100 lb. pressure, unless the oil be so fed into the cylinder as to enter between the valve and the face; even then 50 deg. is high enough.

In modern Corliss engines, where the high-pressure cylinder is properly steam-jacketed and the steam passes around the jacket before entering the cylinder, it is best to carry about 120 deg. superheat for a steam pressure of 160 lb. gage. In many engines of this type, with a good load, the high-pressure exhaust is practically dry but not superheated, so that when the steam in the jacket is giving a reading of 120 deg. of superheat, at the point of cutoff it will be in the neighborhood of 90 to 100 deg.

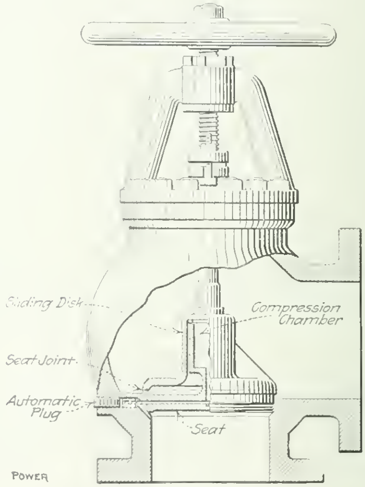
In a plant having cast-iron steam pipes and fittings with a pressure over 100 lb. gage, it is not well to use more than 60 to 80 deg. superheat. In fact it will be far safer to scrap the cast-iron pipes and put in steel, otherwise cracks may develop at the roots of the flanges, especially if the plant is shut down every night.

Before changing a plant from saturated to superheated steam, there are factors which require careful attention, otherwise it may be found that the financial outlay is more than the saving that can be attained.

⁂

Bradford Automatic Nonreturn Boiler Stop Valve

The principal feature of the Bradford automatic nonreturn boiler stop valve is the construction of the automatic disk, seat and plug. The cushion, or compression chamber, in the automatic seat has a small area (see illustration) and is controlled by an automatic plug, adjustable for different pressures. This construction allows ample clearance to the automatic disk and prevents it from seizing the piston over which it slides without the use of a packing ring. At the same time the automatic disk is controlled by the automatic plug.



BRADFORD AUTOMATIC NONRETURN STOP VALVE

Under normal working conditions the steam flow is away from the boiler and its stop valve. When an accident to the boiler occurs the flow is reversed through the valve toward the rupture, causing the valve disk to receive the greatest pressure on its top and it automatically closes to its seat.

Another feature of the valve is its ability to cut in a dead boiler to the line automatically. The valve requires the dead boiler to attain a pressure a few ounces per square inch greater than the pressure in the live boilers, and then cuts it in and equalizes the pressure without attention by an attendant.

This valve is manufactured by the Bradford Manufacturing Co., 384 Atlantic Ave., Boston, Mass.

⁂

Correct Use of the Word "Fitting"—The National Tube Co., in its "Book of Standards," defines the word fitting as "A term used to denote all those pieces that may be attached to piping in order to connect them or provide outlets, etc., except that couplings and valves are not so designated." Plugs and caps used to close an end of a pipe are also included under the term fitting.

Editorials

Manufacturers' Tests

Some manufacturers are sadly deficient in the making of tests and publishing the results of those tests. They seem to be willing to "take a chance" with their products and claim them to be better than competing makes without first making exhaustive experiments to prove their statements.

For example, the maker of a certain appliance advertised it extensively, and it is a very good piece of machinery, but when pressed closely by a prospective buyer, he had to admit that many of his claims were based on his judgment as to the relative values of his and competing appliances made for the same purpose.

The prospective buyer, however, wanted proof, and so before buying anything, obtained consent of the most prominent competing manufacturers to test out their machines in his own way. All of the manufacturers seemed pleased with the idea, so they must have believed in their respective products. Some of them offered to pay the expenses of the "tester," but the prospect preferred to do the whole thing "on his own hook" and thus be under obligations to nobody.

After the tests the manufacturer whose appliance tested best was given the order. Now he is making use of the results of the tests in his advertising. He has something tangible upon which to base his claims and as a result his business is increasing.

It does not seem altogether fair that tests should be "up to the purchaser," as is so often the case. The manufacturer should know what his product can do. He should make comparative tests of his own under the supervision of unbiased authorities, so that there can be no question as to authenticity of results.

Many appliances are sold daily on their "merit," and yet when it comes down to facts the manufacturers themselves cannot give absolute proof of the merit about which they so glibly write and speak. Such a situation is indefensible.

⁂

Recognition for the Engineer

The operating engineer's work is not spectacular, but occasionally it gets a measure of recognition which encourages the man behind the throttle to use his head and study his employer's problems with some hope that inittiative will be appreciated. An unusual instance in which many hours of hard work resulted in deserved advancement has been receiving front-page publicity in the Boston press, to the credit of the modest engineer of the Deer Island steam plant of the Penal Institutions Department, Lawrence Hackett. It seems that for some years past the public authorities at Boston have been considering the desirability of shutting down the five existing boiler plants on the island and building a central heating and power station. The project got so far as to lead to the employment of an outside engineering expert to investigate and report upon the situation, who recommended dismantling the plants now in service and installing an entirely new centralized outfit at an estimated cost of about one hundred and eighty-one thousand dollars.

At times it is better to make the best possible use of means at hand, adding a moderate outlay for new equipment judiciously placed, than to scrap a plant, tear up every existing unit and level present structures. The engineer "on the job" saw this to be the case at Deer Island. He quietly set to work on his own account, obtained private bids on the cost of three new eighty-four-in. boilers installed in one of the existing boiler houses, estimated the saving in fuel and labor by normally supplying all but one remote building of the institution from the new units, holding three good sixty-inch boilers in reserve in another boiler room, with ample tie-line connections between the old and new batteries, and schemed out the elimination of two old boiler plants, with a total reduction in labor of seven firemen and total yearly estimated savings of fifteen thousand dollars. The estimated cost of fixing up the plants according to the new scheme was about five thousand dollars.

A report was then voluntarily submitted to his superiors, favorably passed upon as to its general plan by the consulting engineer of the Boston Finance Commission, Guy C. Emerson, and transmitted to the mayor of Boston. The chief executive of the city was so much pleased with the initiative shown by the author of the report that he promoted him to the position of chief engineer, with a salary increase of fifty dollars per month, and the City Hall reporters "saw a story" in the affair and gave it enthusiastic if technically misguided publicity.

The subject of all this front-page copy was oblivious of its newspaper interest until shown a copy of Boston's most conservative daily by a representative of Power, and, in common with others of his kind, kept right on with his daily duties while others did the talking. The daily press "played up" the engineer's part with too little regard for the concurring professional opinion of the Finance Commission, but this fact in no wise detracts from the credit which the chief executive of the city placed upon the shoulders of the new chief operating engineer, who made no attempt to criticise the views of others but simply presented to his superiors a plain and unvarnished tale of how the city could save an investment of certainly one hundred and seventy-five thousand dollars by effecting various changes in the plant situation as above roughly outlined.

There is an encouraging lesson from all this for the engineer who feels sometimes that the isolated character of his work cuts him off from a fair chance of advancement, and who can see nothing ahead of him but years of routine grind. It is true that advancement does not come even to all who may perhaps be qualified to fill larger and more responsible positions; human affairs are not yet conducted with one hundred per cent. efficiency, and probably they never will be. But never was it more certain that the man who can see an opportunity to make himself more useful and who acts with that aim constantly in view is the one most likely to succeed in the engineering profession, and for the very good reason that in this line of work bluff won't go. It is founded upon great natural laws which are as permanent as anything known to the mind of man, and the engineer must work in harmony with those laws and connect himself in parallel with the stream of progress if he is going to operate in economic synchronism with his fellow seekers after the truth. That is precisely what has been going on at Deer Island, and it is going on everywhere else that engineers are striving to "go the limit" in their services to their employers without measuring their devotion to duty in a chemical balance! Giving good measure, pressed down and running over, is what counts most, and if it is slow in bringing external reward, it none the less follows that the sense of making good goes far to encourage the ambitious worker to keep up his efforts.

⁂

An Ignored Cause of Smoke

Large sums are annually expended in efforts to overcome the smoke nuisance, and many ingenious devices and systems of arches, steam jets, etc., have been devised, some of which have been fairly successful. But all entail more or less first cost and operating expense, and the best of them fail in many instances where smoking occurs only occasionally from some supposedly inexplicable cause.

This "inexplicable cause" is simply foul boiler tubes. Though dirty tubes have long been recognized as seriously hindering the transfer of heat, nevertheless, consideration has not been given the question as a direct cause of smoke. Excess or insufficient air, the cooling of the volatile constituents before thorough ignition of the soot-laden gases takes place, failure to raise the temperature of such gases to that required for combustion—all have been charged as the cause of smoke. Unquestionably these are causes, but they are not the only ones.

When fuel is burned under a clean boiler, the products of combustion and the volatile gases, whether they have been completely consumed or not, pass from the combustion chamber to the boiler tubes, where the transfer of heat takes place. The cleaner the boiler tubes, the more rapid and complete the transfer of heat will be. If soot is carried in suspension, it is deposited on the cleaner sections of boiler tubes, because of the temperature difference. As the soot accumulates, the heat-absorbing capacity of the boiler is gradually reduced, and the hot gases are not so deflected from their natural path and their passage to the smoke flue is not diverted to the tubes to such an extent, because the temperature difference is not so great as formerly and more of the soot is carried past the tubes to the chimney. Precipitation of soot on the tubes thus becomes gradually less rapid, but so also does the transfer of heat to the boiler contents. The result is that the visible smoke increases at about the same rate as the efficiency of the boiler decreases.

Cleaning the tubes restores the heat transfer and at the same time reduces the proportion of soot which would otherwise be carried to the chimney and in many localities lead to trouble with the municipal authorities.

It is true that cleaning the tubes will not reduce the loss due to failure to consume the soot, but avoiding trouble with the authorities is commendable, and it is gratifying to any management to be able to avoid a cloud of black smoke.

The clean boiler is of greater importance, however, and a smoking chimney due to unclean heating surfaces is a signal to turn on the steam hose or to start the soot blowers.

⁂

Superheat

The observations of E. R. Pearce on the use of superheated steam in Corliss engines (page 886), although founded on English practice, may be taken as fairly representative.

Not many years ago, when the advent of the steam turbine brought superheated steam to the fore, its advocates and opponents waged many controversies in which extravagant claims were made on the one side and dire predictions on the other. Subsequent experience has justified neither of these extremes.

Superheat has stood the test, but the theoretical economies of very high temperature have given way to commercial considerations—that is, above a certain point, the gain due to high superheat has often been offset by the additional cost of fittings. Consequently general practice now seems to favor moderate superheat; from 100 to 125 deg. for turbines and 50 to 80 deg. for reciproeating engines. There are exceptions, of course, notably in special cases, such as the locomobile, poppet-valve engines and the Ferranti turbine.

While superheat is now the rule rather than the exception in steam-turbine plants, its use in reciprocating engines is still far from general in this country. Although undoubtedly more effective in the long-stroke, slow-speed type than in the short-stroke, high-speed type, there are many instances of the latter where it might be adopted to advantage. However, here again local conditions, commercial considerations, and sometimes prejudice, are deciding factors.

Many comparative tests have been made on engines running with and without superheat, which have invariably shown a lower steam consumption with the former. But this does not tell the whole story, for it does not show the cost of producing the superheat. This is comparatively easy to figure and the net saving is usually taken as about one-half the decrease in steam consumption. The absence of sufficient test data to verify this, however, has probably made many plant owners hesitate in deciding on superheat; for, after all, the average plant owner is "from Missouri."

⁂

We were accused the other day of printing something that was "not fair, nor correct, nor honest." Our reply was that we never printed anything unless it was all three of those, if we knew it, and that if we should find we had unwittingly done so, we would make all amends possible immediately. To put all the emphasis we can on this statement we are hereby making it a public declaration of principle. We have been working on this policy ever since the first issue of POWER appeared, and we wish to assure our readers that we are as jealous of our reputation for rectitude as ever. When we find we have made mistakes we acknowledge them.

Correspondence

Cranks and Criminals

The perpetual-motion crank proposes to produce energy where none existed before—making something out of nothing. Likewise the schemes that are periodically proposed to convert ashes into fuel by the addition of a magic chemical compound. An analysis of some of these compounds would probably disclose as one of the ingredients, the left hind foot of a rabbit or some equally potent "charm." These schemes are always proposed by ignorant or unscrupulous men.

So much has been said about so called accidental inventions that many people put in a great deal of their time tinkering with mechanical contrivances hoping to make a lucky strike. In most of these cases a knowledge of the rudiments of mechanics would save the afflicted much time and money.

C. O. Sandstrom.

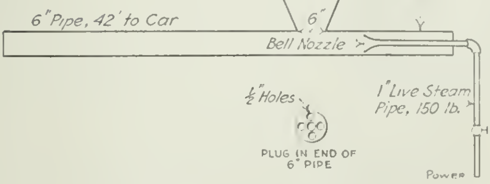
Kansas City, Mo.

Live-Steam Ash Ejector

We tried out the scheme shown, and could not get it to work. Will some one who is successfully blowing cinders with high-pressure steam tell us what the trouble is?

We have a bucket elevator to carry cinders from the basement of the boiler room to a screw conveyor, delivering the cinders to the rear of the building, and as we could not have a track at this point, we have to drop the cinders on a platform and wheel them to the car.

We cut a hole in a 6-in. pipe and built a hopper 4 ft. high and 4 ft. wide above and secured it to the pipe, terminating at the bottom with a 6x6-in. opening.



Ash Ejector Failed to Work

Entering the end of the 6-in. pipe is a 1-in. steam line with a bell nozzle, the end of which is 18 in. from the hopper opening. The 6-in. pipe is 42 ft. long and is nearly level. The elevator was started and the live steam turned on, but the cinders would not blow through as the condensation of steam would wet the fine ash, completely plugging the 6-in. line, and the steam blew out at the hopper. Our steam pressure is 150 lb.

We have also tried several other arrangements—closed the air opening in the flange through which the steam pipe enters the 6-in. pipe, advanced the nozzle gradually up to and even beyond the hopper opening, and finally used a 6x6x4-in. tee at the junction of the ejector pipe, and a hopper with a 12-in. piece of 4-in. pipe between the tee and the 1-in. steam pipe. This was all to no purpose; the ejector will not eject.

Have any readers used steam successfully for blowing ash in this way?

E. H. Clark.

Harrisburg, Ill.

Engine Salesman's Experience

The Corliss engine builders for whom I worked received a letter of inquiry from what was evidently a very peculiar, if exacting, prospective purchaser; his letter read as follows:

> Gentlemen: I am in the market for an uptodate steam engine of two hundred horsepower capacity. It must be uptodate and more economical than the regular Corliss engine kind. If you can build such an engine send your representative.
>
> Yours in haste,

On the face of it, the inquiry looked so good that I went by the next train for an interview. On entering the prospective customer's office, I was surprised to find that it occupied a space of only about ten by sixteen feet and was furnished with a table, holding the upper part of a rolltop desk, in company with two chairs, a letterpress and a peculiar and somewhat shrewd looking man. I include him in the furnishings because he looked cold enough to be one of them.

After going through the usual formalities, he finally asked me to be seated and wanted to know if I was in a position to talk with authority on his proposed installation, carefully explaining that if such were not the case I would waste my time and his also. I assured him that I was there prepared to talk business. He yawned, closed his eyes and wanted to know why engine builders in this country could not get as good economy with compound and triple-expansion engines as they obtained in Europe with single-cylinder units. I tried to tell him he was misinformed, but he slapped his fist down on the desk and warned me not to argue as he knew what he was talking about.

He said he was dissatisfied with the economy they got in Europe even; he wanted something better and had been thinking for a long time of a type that would revolutionize steam-engine practice. Now that he required more power in his stone quarry, he wanted a builder who would incorporate his ideas in the unit. I intimated that a special design (I did not like to say freak design, because it might hurt his feelings—and he was bigger than I am) would cost much more than one of regular design. He answered that he did not care, as the saving in fuel would soon pay the difference.

He explained that the "thermos bottle" gave him the idea, which was to make an engine having jacket space around the cylinder barrel and heads and instead of using steam in the jackets, to have them connected to an air pump, so as to produce a vacuum and therefore eliminate the transfer of heat between the barrel and the outside and reduce condensation.

I left him with the understanding that I considered him a genius and would try it on the jacketed cylinder of a pumping engine, which I knew I could use for the experiment.

A friend, who is superintendent of a pumping station, gave me permission to use the Corliss engine, and after setting the valves properly, we took some indicator diagrams with the engine running noncondensing and high-pressure steam in the jackets of the barrel and heads. We then connected the vacuum pumps to the jackets and found that with 20-in. vacuum in the jackets the diagrams were not nearly as good as before, and the engine used much more steam in the cylinder when vacuum was used than with the steam jackets.

I wrote the prospective purchaser fully on the subject and about a month afterward received a reply stating that he had just purchased a second-hand slide-valve engine, which I found afterward had been in service about twenty years.

M. E. Griffin.

Franklin, Penn.

Separator Drain as Steam Supply to Pump

In a small plant in Oklahoma the trap on the drain from the steam separator for the 16x36-in. Corliss engine was out of order. I suggested connecting the separator drain as a steam supply to the feed pump and the exhaust from the pump to the open feed-water heater. When this was done we were no longer bothered with wet steam in the engine.

J. Talla.

Mesa, Ariz.

The Fireman Is a Chemist

A good place for a young man to begin his engineering experience is in the boiler room as a manufacturing chemist, for that is what a fireman really is. He uses air composed of hydrogen, oxygen and nitrogen, and coal composed of fixed carbon and hydrocarbons, the latter consisting of olefiant gas, pitch, tar, naphtha, etc. He separates the hydrocarbon from the fixed carbon and endeavors with the means at his disposal to combine one atom of carbon with two of oxygen, and two atoms of hydrogen with one of oxygen, forming respectively CO_2 and H_2O.

In handling the hydrocarbons, he must be careful to supply a sufficient number of atoms of oxygen, otherwise the carbon will form a fine powder called smoke. When this takes place it is usually too late to supply the oxygen and the smoke remains. This visible loss in itself is not so much unless the smoke is deposited on the heating surfaces of the boiler. Then the loss is considerable, as the heat insulating value of soot is about five times that of fine asbestos. Another reason why the fireman must be careful is that if he should combine one atom of carbon with only one atom of oxygen, the heat value, or result in B.t.u. per pound of combustible, will be 4400 instead of 14,500.

But perhaps it is better in these days when encroachments are resented, not to say much about chemistry; the chemists may proceed to brand the engineering profession for their own benefit, and a fireman will then have to be a "D.Ph." and serve some months behind a drug counter.

R. McLaren.

Toronto, Ont.

Trouble with an Air Lift

In the Oct. 6 issue, page 504, Mr. Lacy describes his difficulties with an air lift. The system of piping employed by him is excellent and would afford good efficiency where care is exercised in the selecting of pipe diameters and proportioning the submergence. Unfortunately, both of these important points are often overlooked by engineers. Instances of the difficulties referred to have been brought to the writer's attention a number of times. Of course, it will be impossible to prevent the forming of a precipitate, for this is caused by the oxidation of impurities in the water, but the recurrence of sudden and expensive shut-downs may be prevented by installing the air line as shown in Fig. 1.

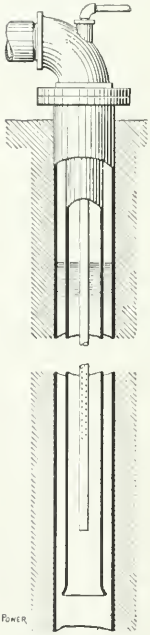


Fig. 1. Perforated Air Pipe with Open End

As indicated, a section of blank pipe is extended below the perforations in the air line and the lower end is left unplugged. Thus any scale or dirt may escape downward and no air will reach the end; instead, it will follow the path of least resistance, which is through the holes. Should a coat of scale form on the inner surface of the air line and gradually restrict and finally clog the perforations, the air will travel down to the pipe end and the well will continue to operate. This condition may be immediately detected on the air gage and the air line may be withdrawn at a time convenient to the operator.

An analysis of the well characteristics and the rather indefinite operating conditions stated by Mr. Lacy, would lead one to believe that the best efficiency is not being obtained. For instance, it is said that the water comes within 30 ft. of the top of the well and that there was 136 ft. of 1-in. air line. It is not stated, however, whether the 30 ft. is the static or pumping head. If it is the pumping head, then as the air-pipe perforations were at an average depth of about 134 ft., the depth of submergence is 104 ft. (134—30 ft.), and neglecting the slight pressure reduction due to established column momentum and the pressure increase due to column friction losses, the operating pressure should be about 106 × 0.434 = 46 lb. The actual operating pressure is given as 60 lb.

This means that between the air gage and the lower end of the air line there is a pressure loss of 15 lb., which would seem excessive.

The percentage of submergence was approximately 77 (104 ÷ 134), which is about right, but to this 36 ft. was added, increasing the percentage of submergence to about 82 (140 ÷ 170), which is too high. In this connection it is interesting to note the curves reproduced in Fig. 2. These curves were plotted from results obtained by the writer in a number of tests of the perforated air-line system of pumping. The upper is the submergence curve and is drawn through the points that were found by experiment to be the most advantageous; the lower is the efficiency curve and is drawn through points that represent the efficiency obtained under various pumping heads when employing the submergence indicated by the upper curve.

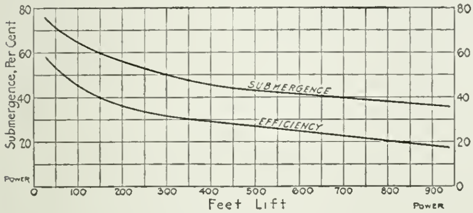


Fig. 2. Efficiencies for Different Percentages of Air-Pipe Submergence

These curves must not be understood to be absolutely correct for all cases, as local conditions in any installation may demand a deviation, but they will be a good guide and one cannot be far wrong by following them closely wherever possible.

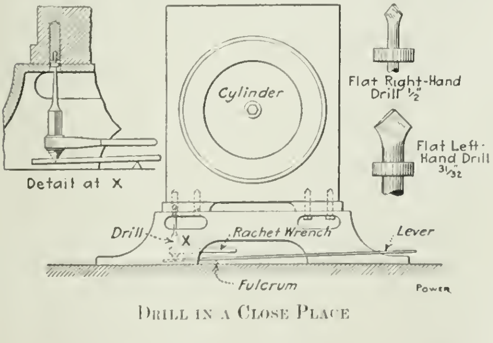
E. M. Ivens.

New Orleans, La.

Replacing Broken Capscrews

A 22x42-in. Corliss engine broke the capscrews that hold the cylinder on the pedestal at the crank end outside, and left about $1\frac{1}{2}$ in. of stubs in the holes.

The problem was to get them out in the shortest possible time. A ratchet drill would not go into the space between the feet and allow the handle to work between the casting and the floor. As we had a ratchet wrench, we had two drills forged with square shanks to fit it. One drill was $\frac{1}{2}$ in. and the other $\frac{31}{32}$ in. (the bolts were $1\frac{1}{8}$ in.). We used the $\frac{1}{2}$-in. first, then the $\frac{31}{32}$-in., which was ground to turn to the left. The object was to have the drill tend to loosen the stubs instead of tightening them.



Drill in a Close Place

After we had drilled about an inch with the $\frac{31}{32}$-in. drill the stub backed out, leaving a nice, clean thread. We used a long bar and fulcrum for the drill feed. The illustration shows the means employed.

C. L. Juno.

Milwaukee, Wis.

Air in the Suction Pipe

I have read with interest the article by George H. Gibson on the hundred-million-gallon centrifugal pump for Pittsburgh, in the Nov. 3 issue. Mr. Gibson stated that "due to the small size of the intake and to low water, a certain amount of air entered the suction pipe, probably reducing the capacity and also the duty."

A pump in a plant where I was employed was driven by a cross-compound engine. It had been in service about two months when the testing engineer for the builders arrived and prepared the engine and pump for a test. He made preliminary trials a few days before the official test and knew what duty and capacity to expect. The test was started on the date set and ran for two hours, when the testing engineer called it off, as the pump was not making its duty and capacity on account of air in the suction pipe.

The air leak was around the edge of the seat of a valve that had been connected on the open end of a Y inserted (for future extension) into the suction pipe during the interval between the preliminary and the official test. The record of the test while the pump was getting air showed a decrease in duty of 0.125 per cent., and in capacity of 0.094 per cent.

Lawrence Kjerulff.

Kansas City, Mo.

Wooden Packing Rings for Pumps

While few engineers use wooden packing for the water end of vacuum pumps, it is one of the best of packings if properly put in, as the pumps will run with but little friction. It should be made to fit perfectly between plates 1 and 2, Fig. 2. In Fig. 1 it will be noticed that a spring is used for tension on the blocks to set them out against the cylinder walls. This spring is best made of brass ribbon about No. 20 gage in thickness, as it will not rust out like a steel spring. The wood should be hard and close grained, and therefore will not split readily. A set of these rings will last several years if properly made.

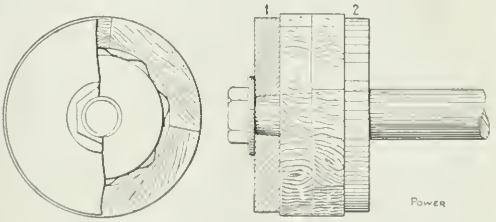


FIG.1. FIG.2.

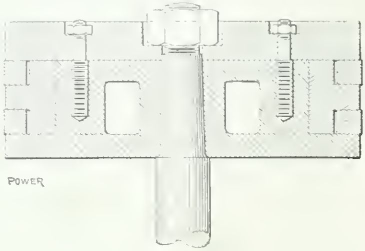
Plunger with Wooden Packing

C. R. McGahey.

Baltimore, Md.

A Knock Difficult to Locate

In a vertical compound engine running at high speed a severe knock developed. After the engine had received attention at almost all other points the high-pressure cylinder head was removed. The piston was of the built-up type, the follower plate being held in place by six ½-in. studs riveted over to prevent the nuts working off. In this case, however, one of the studs had worked out with the nut, and instead of knocking the cylinder head out the nut had been crushed, the piston rod bent and the piston loosened, giving it about $\frac{3}{32}$ in. lost motion.



Piston with New Studs

A new rod was ordered, and to prevent another accident all the studs were removed and the ½-in. holes reamed and tapped for ⅝-in. studs; these were reduced at the surface of the piston body to fit the ½-in. holes in the follower plate, which was put on as before and ½-in. nuts used.

Now there is no way for the studs to come out except for all six to work out at once, which is not probable.

Edward T. Binns.

Philadelphia, Penn.

⁂

Using a Discarded Feed Pump

On taking charge of this electric plant, I found an old duplex boiler-feed pump that had been discarded. After cleaning the scale and lime out of it, I believed that it could be made fairly good at little expense.

As we had but one pump for feeding the boilers and an injector as a reserve feeder, I set up the old pump and had it on its foundation by the time the superintendent had the new parts. It has two intake and two discharge openings, so I connected one pair to feed the hot water to the boiler; the other intake I connected to the city water and also into the flywheel pit, with shut-off valves on each. When it rains heavily, the water runs into the wheel pit, but we can now pump it out with the steam pump instead of the old pitcher pump. The other outlet has a 1-in. hose connected for washing boilers.

R. F. Peterson.

Knoxville, Iowa.

⁂

Improperly Finished Pumps

Why do pump makers send out unfinished pumps? The writer has five pumps made by one of the best-known American builders and each had to be partly rebuilt, the pins and other parts of the valve motion case-hardened and fitted with grease cups. In a pump situated where there is danger of coal or other dust, if fitted with grease cups the motion work will run for a long time, as the grease prevents dust from getting into the joints, the tendency being to work out at the ends of the bearings and seal them. Again, the stuffing-boxes are, as a rule, shallow and have flat bottoms; also, the gland faces are finished off square instead of being given an angle of about forty-five degrees, which helps to keep the packing up to the rod without undue pressure.

The valve disks, when of metal, are almost always too light and soon buckle up and leak. After new valves have been fitted and steel studs put in to hold the cover on the water end, these pumps do well. The rods and studs are made in large lots on automatic tools from soft, cold-rolled stock, which has very little life in it, whereas for a few cents more, good material might be used.

E. R. Pearce.

Rochdale, England.

⁂

Marking Ammeters

Engineers in charge of alternating-current apparatus furnishing current to systems characterized by a low power factor, as shown by a considerable difference between the "kv.-a." and the "kw." readings, should have the safe maximum limit in amperes marked in red upon all ammeters. This will tend to obviate the practice of operators depending upon the wattmeter readings for the capacity of the apparatus, which is attended with danger on account of the heating effect of the wattless current.

John F. Hurst.

Louisville, Ky.

⁂

Condition of Some Plants in New York City

On taking charge of a small steam plant in New York City, I found its general condition bad, due to bad management by poorly paid help.

The first things I noticed were poor boiler draft leaky tubes and wasted return water. After repairing the brickwork and leaky tubes, and when all the returns were connected up, one boiler did the work of two. By the use of No. 1 buckwheat instead of pea coal, a reduction of 22 per cent. in fuel cost was made. The refrigerating plant was also in bad shape, a 6-ton water cooler giving only about 200 lb. of water at 40 deg. F. before the temperature went up 6 or 8 deg. Repairs to crankpin boxes stopped the pounding, all expansion valves were set to the pipe coil capacity and freezing back was reduced.

The cooler was next looked over. The inlet was at the top of the head and the outlet at the middle. Consequently, when cold water was drawn it was followed by the warmer water from the upper part of the tank; that is, the tank was upside down. It was turned over and the outlet connected at the bottom, the result being that it cooled 2500 lb. of water from 70 deg. to 40 deg. F. per hour.

The management claimed it could not get good operating engineers, but after a trial of a month, I was then paid 30 per cent. more than the former engineer.

C. W. Roos.

New York City.

Inquiries of General Interest

Calorific Value of Fuel—What is meant by the calorific value of a fuel?

R. J.

It is the amount of heat or number of B.t.u. liberated per pound of the fuel when undergoing perfect combustion.

Pumping Hot Water—When a pump is to handle hot water, why should the supply be above the level of the pump?

H. G.

So that the water may run into a water cylinder by gravity, for if the supply is placed below the pump, the suction stroke will reduce the pressure on the supply and cause the water to evaporate. The vapor thus given off flows into the pump cylinder, preventing the water from filling the cylinder.

Loss from Incomplete Combustion—What is the difference in the amount of heat realized by burning carbon to CO and to CO_2?

H. D. R.

When carbon unites with oxygen to form CO there are only 4400 B.t.u. given off for each pound of carbon burned, but when the carbon is burned completely to CO_2 there will be given off 14,500 B.t.u. for every pound of carbon burned.

Grades of Steam Pipe—What are the commercial designations of different kinds of steam pipe with respect to pressures for which they are suitable?

G. C.

There are three regular thicknesses or weights, viz.: Standard, which is suitable for pressures up to 125 lb. per sq.in.; extra strong, which is suitable for pressures up to 250 lb. per sq.in., and double extra strong, which is suitable for pressures up to 800 lb. per sq.in.

Grate Surface for Return-Tubular Boiler—What proportion of grate surface should be provided for a hand-fired return-tubular boiler?

R. M.

For developing a fair capacity of the boiler with ordinary chimney draught—i.e., not exceeding about 0.3 in. of water column at the damper and burning anthracite coal or poor varieties of bituminous coals, and with ordinary settings—for a hand-fired grate, not less than 1 sq.ft. of grate surface should be furnished for 30 sq.ft. of boiler-heating surface.

Mercurial Thermometers for Flue-Gas Temperatures—Why cannot ordinary mercurial thermometers be used for obtaining flue-gas temperatures?

J. R.

Mercury boils at about 676 deg. F. and atmospheric pressure, and the ordinary types of mercurial thermometers are unsuitable for measuring temperatures above 500 deg. F. For higher temperatures up to about 800 deg. F., mercurial thermometers are made with the space above the mercury filled with nitrogen gas, and as the mercury expands, the gas is compressed, thereby increasing the pressure and raising the boiling point.

Run Grain Side of Leather Belt on Pulley—Which is the right way to put a leather belt on the pulley? Should the smooth or rough side go next to the face of the pulley, and why?

P. L.

The "hair" or smooth side should go next to the pulley as it is harder and will better withstand the wear from slippage and attrition, besides which the flesh side of most leather belts is stronger at the surface of the leather and placed on tho outside will not part or crack so readily. If the smooth or grain side becomes actually worn off it will usually be beneficial in removing the tendency to formation of surface cracks which, once formed, will rapidly extend themselves into the body of the belt.

Capacity of Hydraulic Elevator—If a high-pressure hydraulic elevator is operated with 750 lb. per sq.in. pressure acting on an 8-in. diameter plunger which is geared 6 to 1, would the actual lifting capacity be as great as 3500 lb.?

W. T. O.

The cross-sectional area of the plunger being

$$8 \times 8 \times 0.7854 = 50.265 \text{ sq.in.}$$

and the total pressure acting on the plunger being

$$50.265 \times 750 = 37{,}698.75 \text{ lb.}$$

then, as the elevator is geared 6 to 1, neglecting friction, the lifting power of the elevator would be one-sixth of 37,698.75, or 6283.12 lb. An actual lifting capacity of 3500 lb. would be realized with an efficiency of $\frac{3500}{6283.12}$ or about 56 per cent. With good design, workmanship and materials, and proper adjustment and operation, the efficiency stated should be attained and the actual lifting capacity should be at least 3500 lb.

Value of Constant in Formula for Flow of Steam—What would be the value of K in the formula

$$W = 1.9\, AK \sqrt{(p - d)\, d}$$

sometimes used for finding the weight of steam flowing from a higher to a lower pressure where the lower pressure is greater than 58 per cent. of the higher?

D. P.

Where

W = The weight of steam discharged in pounds per minute;
A = Area of orifice in square inches;
P = The absolute initial pressure in pounds per square inch, and
d = The difference in pressure on opposite sides of the orifice, in pounds per square inch,

then K may be taken as a constant equaling 0.93 for discharge through a short pipe, and 0.63 for discharge through a hole in a thin plate.

Pounding of Engine when Run Condensing—What may be the reason that our 22x36-in. corliss engine cannot be run condensing unless the valves are set with more compression of the exhaust than is required for running the engine noncondensing without pounding?

H. M. J.

With the same valve setting the cushioning effect of compressing the exhaust will be less when running condensing, and in addition there will be a greater tendency for production of a pounding noise from the sudden admission of steam of the same initial pressure into the clearance spaces of the cylinder when filled with exhaust steam, compressed to a lower pressure than when running noncondensing. When there is sufficiently high compression of the exhaust to take up the back lash of the working parts by cushioning, then pounding of this kind will usually be remedied by a more gradual admission of the initial steam, but where this is impractical or undesirable, the remedy is to increase the compression of the exhaust.

Fusible Plugs for Return-Tubular Boilers—How should fusible plugs be made and where should they be located in horizontal return-tubular boilers?

E. C. S.

In most localities where boilers come under governmental regulations the material, form and location of fusible plugs are subjects of special requirements. For a horizontal return-tubular boiler, one or more fusible plugs should be located in the rear head not less than 2 in. above the highest part of any tube, measuring to the center of the fusible plug. The shell for a fusible plug should be made of phosphor bronze or a high grade of brass which will not be affected by the furnace gases, the shell having an external diameter of not less than ¾-in. pipe tap and of sufficient length to project at least 1 in. inside of the boiler and provided with a close hexagon head for setting the plug with a wrench from the outside. The fusible metal should be pure banca tin, the melting point of which is about 445 deg. F., and it should extend the full length of the bronze shell with a diameter of at least ½ in. at the inner end of the shell, and be gradually enlarged at the center or at the outer end of the plug.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention. EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--X

DETAILS OF DIRECT HEATING, PIPE MAINS AND CONDUITS

The principal details relating to direct heating are the methods of computing the radiating surface, types of coil and radiators, systems of piping, location of radiation and connections, and air venting.

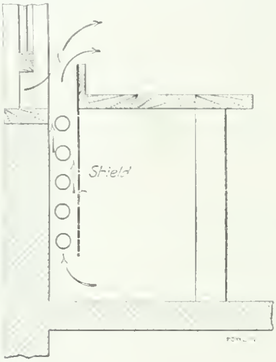


FIG. 1. GOOD LOCATION FOR COILS IN SHOP HEATING

COMPUTING RADIATING SURFACE

This is most correctly done by dividing the total heat loss per hour from the room or building by transmission and leakage, as determined by the methods given in article IV, by the heat given off per hour in B.t.u. per square foot of radiating surface. It is common to use 250 for cast-iron radiators and 200 for pipe coils, supplied with low-pressure steam.

When wrought-iron pipe coils are used, square feet of radiation must be reduced to linear feet of pipe, which may be done by use of the following factors:

Size of Pipe, In.	Multiply by
1	3.0
$1\frac{1}{4}$	2.3
$1\frac{1}{2}$	2.0
2	1.6

For example, a coil having 100 sq.ft. of radiating surface must contain 100 × 2.3 = 230 lin.ft. of $1\frac{1}{4}$-in. pipe, or 100 × 2 = 200 ft. of $1\frac{1}{2}$-in. pipe, and so on.

TYPES OF DIRECT RADIATING SURFACE

In the case of industrial plants the sectional cast-iron radiator is only used in offices, supply rooms and other locations where a comparatively small amount of radiation is required, or where it is desired to keep the larger part of the wall surface free and concentrate the heat in one or more places.

Coils of $1\frac{1}{4}$- or $1\frac{1}{2}$-in. pipe are commonly used in this class of work, being less expensive to install and distributing the heat more evenly in large spaces. They are most effective when carried along the outer walls beneath the windows, as the heat is delivered near the floor with this arrangement. A specially good plan for a shop is shown in Fig. 1. Here the coils are placed on the walls back of the benches, with a shield in front to prevent the heat from coming out beneath the bench and rising into the workman's face. A space is left next to the wall and the air circulates over the coil as indicated by the arrows.

By opening the windows slightly (as shown) good ventilation may be secured without uncomfortable drafts, as the sheet of hot air rising from the coil mixes with the entering air and carries it upward, thus preventing it from striking directly upon those in front. Coils of this kind are made up with cast-iron headers, and provision must be made for expansion, either by carrying them around a corner or turning the end up and extending it vertically a short distance.

When a single coil will not give the required amount of heating surface in the available space, a double coil may be used, one being placed in front of the other.

Overhead coils are employed when it is desired to keep the walls entirely free, as in storerooms, etc. Heating surface is not as effective when placed in this location, as the heat rises while the stratum of air near the floor remains cold. This, however, is not usually a matter of great importance in the buildings or rooms where this type of coil is used. When employed in occupied rooms, where it is necessary to warm the lower part as well as the upper, it will be necessary to increase the computed surface about 50 per cent.

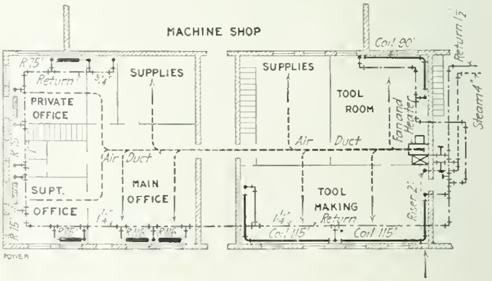


FIG. 2. PIPING FOR HEATING AND VENTILATION—FIRST-FLOOR PLAN, OFFICE WING

SYSTEMS OF PIPING

When a vacuum system of heating is used it is necessary to provide two connections for coils and radiators, but when run on a gravity return the cast-iron radiators may have a single connection. When a suction is attached to the main return, the discharge outlet from each coil and radiator must be provided with a thermostatic or motor valve which opens only to allow the discharge of air and water, but closes in the presence of steam. Valves of this kind should also be placed on each drip pipe discharging into the main return. When a vacuum system is employed, all direct radiators in occupied rooms should be provided with a graduated valve so that the amount of steam admitted may be varied to a certain extent and thus make it possible to regulate the temperature of the room. In large rooms the coils are sometimes arranged in groups, each one of which is provided with a graduated valve and under the charge of a person assigned to its use, and whose duty it is to see that a proper temperature is maintained within the building.

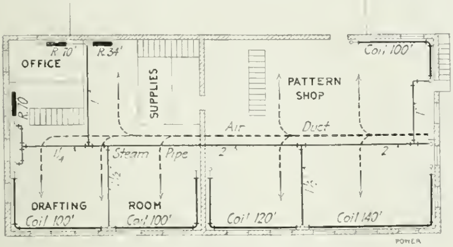


FIG. 3. SECOND-FLOOR PLAN

With a two-pipe vacuum system it matters very little whether the radiation is placed on an "up supply" or "down supply" so long as the general principle of supply and return is carried out. As many shops have no basement it is usually more convenient to run the supply pipes overhead and carry the returns in covered trenches beneath the floor.

A practical illustration of a system of direct radiation with an overhead supply is shown in Figs. 2 and 3, which represent the first and second floors, respectively, of the office wing of our model plant. The sizes of radiators and coils in the different rooms were computed as previously indicated, the heat loss for the different departments being taken from Article IV. Cast-iron radiators have been used in the offices and some of the smaller rooms, while wall coils have been employed in the pattern shop, drafting room, etc. The steam supply is first carried to the top of the building through a single riser at one end, where it branches and connects with the different supply drops. Each radiator and coil, and the bottom of each supply drop, are connected with the main return through a thermostatic or motor valve.

The return is carried beneath the floor of the first story, but all thermostatic valves in pipes connecting with it should be above the floor so as to be accessible for inspection and cleaning.

The ventilating fan and heater for this section are placed on the floor in the toolroom and supply air at a temperature of 68 or 70 deg. to the different rooms through distributing ducts carried at the ceilings of the two stories. All heating is done by the direct radiation, the warm air being for ventilating purposes only.

This arrangement is employed for this section of the building because a higher temperature is carried in most of the rooms than in the main shop, and a more accurate temperature regulation is required in the offices and drafting rooms where the occupants are less actively employed. Under these conditions the system is more easily handled for a number of rooms by separating the heating and ventilation as in the present case.

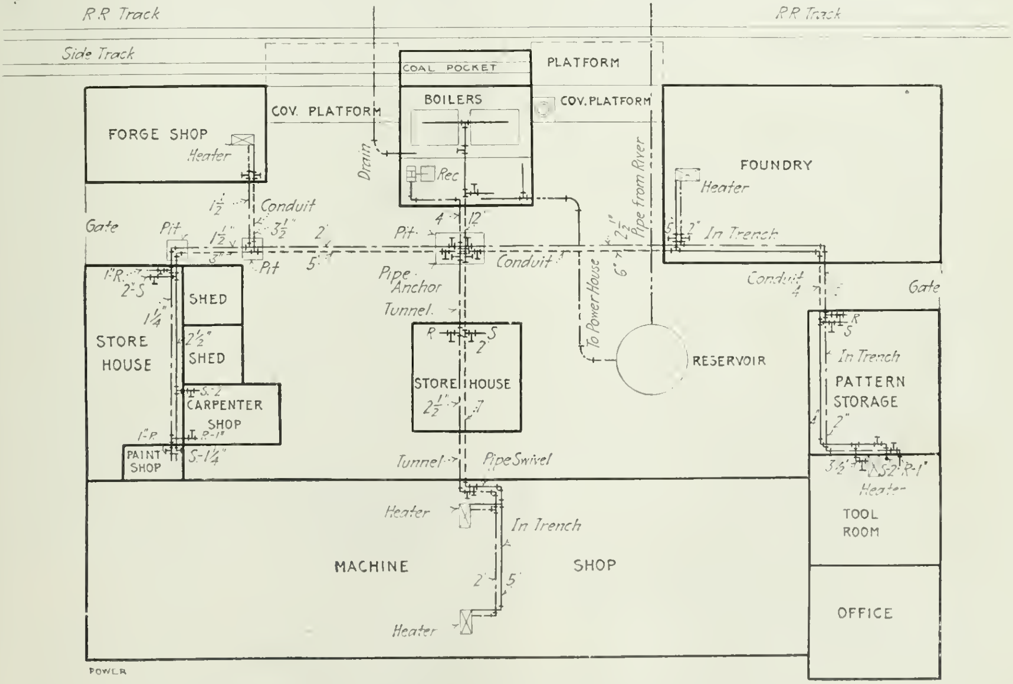


FIG. 1. GENERAL LAYOUT OF HEATING MAINS

Details of the heating in the carpenter and paint shops, storehouses, etc., are not worked out. It is assumed that these will be equipped with coils proportioned on a basis of 300 B.t.u. per sq.ft. of surface per hour, and located either on the walls or overhead as found most desirable.

PIPE MAINS

A general layout of the pipe mains supplying the different buildings and departments is shown in Fig. 4.

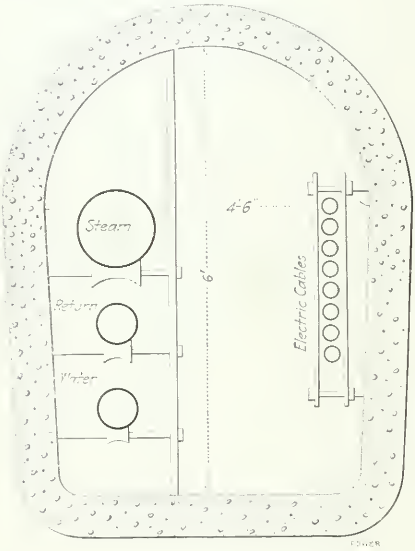


FIG. 5. SECTION THROUGH PIPE TUNNEL

Starting at the power house a 12-in. supply main is carried through a tunnel to a walled pit, where it is anchored, and then branches in three directions, one leading to the forge shop, carpenter shop, etc.; one to the foundry and office wing; and one to the machine shop. These pipes are carried underground either in tunnels or conduits as indicated on the plan. Where they pass through the various buildings they are run either in covered trenches or along walls as may be necessary to avoid fixtures and to maintain the proper grade. In the machine shop both pipes are carried across the building in a trench in order to clear the traveling crane.

Expansion is provided for by offsets, and a special swivel just inside the machine-shop wall. Being anchored in the central pit, the mains expand in all four directions, and the increase in length thus being divided into four parts is easily cared for.

Pipe sizes for vacuum systems of the type used in the present case may be taken from Table 1, which applies to lengths of run up to about 400 ft.

The sizes given in Fig. 1 have been taken from this table, which are slightly larger than used by some of the patented systems of vacuum heating.

In the case of a gravity system of heating, where the condensation flows back to the receiver without the use of a vacuum pump, the sizes as in Table 2 may be used for runs up to 100 ft., with steam pressures of 3 to 5 lb. gage.

TABLE 1—PIPE SIZES FOR VACUUM HEATING

Pounds of Steam per Hour	Steam Pipe, In.	Return Pipe, In.
50	1½	¾
120	2	1
220	2½	1¼
350	3	1½
550	3½	1½
800	4	2
1,100	5	2
2,500	6	2½
3,500	7	2½
5,000	8	3
7,000	9	3
9,000	10	4
15,000	12	4

TABLE 2—PIPE SIZES FOR GRAVITY LOW-PRESSURE HEATING

Pounds of Steam per Hour	Steam Pipe, In.	Return Pipe (Dry), In.
60	1½	1¼
180	2	1½
300	2½	2
500	3	2½
800	3½	2½
1,000	4	3
2,000	5	3
3,000	6	3½
4,600	7	3½
6,500	8	4
8,800	9	4
11,500	10	5
18,500	12	5

TUNNELS AND CONDUITS

The method of constructing the underground conduits in a plant of this kind is a matter of much importance. In deciding upon the best construction the matter of durability should be considered as well as first cost.

In the present case a tunnel has been provided between the power house and machine shop on account of the large size of the pipes and also for carrying the electric cables. This makes a passageway between the two buildings and provides access to the brick pit where the anchor and main valves in the various branches are located.

A section through this tunnel is shown in Fig. 5 and illustrates the method of supporting the pipes and cables. The walls are of concrete and the dimensions are such that ample space is provided for a man to pass through.

There are four general types of conduits employed where the pipes are carried underground without means of access; those of wood, cement, vitrified tile, and a combination of tile and cement. Some of the various makes on the market are shown in Figs. 6, 7 and 8.

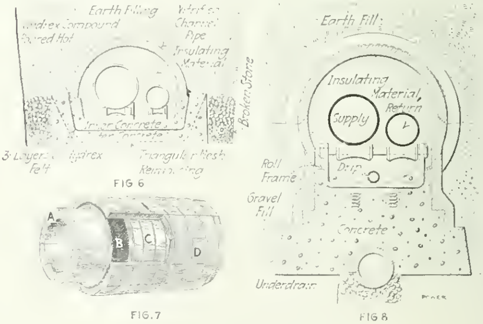


FIG 6

FIG.7

FIG 8

UNDERGROUND PIPE COVERING

Fig. 7 shows a wooden conduit which also serves to insulate the pipe. This type requires a separate conduit for each pipe. Fig. 6 shows another form of conduit. This is of combined concrete and tile construction, with special attention given to waterproofing. A split-tile conduit is shown in Fig. 8. In this case both steam and return pipes are carried in the same conduit and the space around them is packed with insulating material.

The life of a wooden conduit depends largely upon the quality of the material the method by which it is prepared to resist decay, and the amount of moisture in the soil surrounding it. Wooden conduits have been found, in some cases, to be in good condition after 20 years or more of service, while in others they have deteriorated quite rapidly. With the best of material and construction, and proper underdraining, it would seem that the longer period mentioned should be approached in a majority of cases. The best forms of concrete conduit have a life much beyond that of the pipes which they contain. If they are of such form that they must be replaced when the pipes are, there is, of course, no advantage in greater durability. If, however, the pipes may be renewed by simply removing the cover from the conduit, without disturbing the principal part of the construction, as in Fig. 8, for example, durability beyond the life of the pipe becomes an important factor.

*

Recent Developments in Steam-Electric Generating Stations

On the evening of Oct. 28, John Hunter, chief engineer of power plants of the Union Electric Light & Power Co., St. Louis, gave an interesting address on the above subject at a joint meeting of the Associated Engineering Societies of St. Louis, held under the auspices of the St. Louis section of the American Society of Mechanical Engineers.

Mr. Hunter summarized the equipment of the large generating stations, of New York, Boston, Philadelphia, Washington, Detroit, Milwaukee, Chicago and St. Louis, and amplified his remarks with 110 carefully selected lantern slides. The lecture was so well received that even an abstract should prove of interest. Mention of the various stations has been made in these columns, but a brief review of the big steam plants of the country in one article will bear repetition.

NEW YORK WATERSIDE STATIONS

At present there are 15 different public-service corporations supplying power to the five boroughs of the city of New York. The New York Edison Co., operating the great Waterside stations, is of first interest. Its history of development dates back almost to the beginning of the electric-light industry. The old Pearl St. station, the first Edison electric-lighting station in New York, was built in 1882. Up to the advent of high voltage, alternating-current transmission and distribution, there were numerous steam stations of the noncondensing type for direct-current generation built here and there about Manhattan Island. The Duane St. station is an example. It is made up of 2500-hp. vertical condensing engine units. The first plant of any considerable size was Waterside station No. 1, built in 1900 and designed for sixteen 3500-kw. alternating-current generators driven by vertical compound engines. In 1905, after eleven of these units had been put in, the equipment was completed by the addition of three 5000-kw. vertical turbines and two 10,000-kw. horizontal turbines. In 1911 and 1912 four of the engine units were removed and three 20,000-kw. vertical General Electric turbine units installed. At the same time one of the 5000-kw. turbines was rewound for 9000 kw. The total capacity of the plant is thus 123,500 kw. The station is designed for fifty-four 650-hp. boilers, on two decks and set in batteries of two. The furnace equipment is both Roney and Taylor stokers.

This station was rapidly outgrown and Waterside Station No. 2 was built in 1909. It adjoins the No. 1 station and together, so far as operation is concerned, they are practically a single station, forming the largest steam plant in the world and having a combined capacity of about 215,000 kw.

In No. 2 station the boiler house contains ninety-six 650-hp. Babcock & Wilcox boilers operating at 200 lb. pressure with 125 deg. superheat. Thirty-six of the boilers were originally fitted with flat grates, commonly called straight draft, for hand firing, while the remainder have the Taylor stokers. The boilers are in eight rows across the boiler house, six in a row and on two decks. There are four stacks, each serving 24 boilers, 12 boilers on each deck. There is no railroad track service for these stations, the coal being brought in barges from coal docks in New Jersey From the barges it is lifted to overhead bunkers and falls by gravity to the boiler hoppers. The ashes are dumped from the pits into cars in the boiler room basement and drawn by an electric locomotive to a pocket from which they are conveyed to an overhead ash bunker and then dumped into barges for final disposition.

In the turbine room there are six 8000-kw. Curtis turbines, two 8000-kw. Westinghouse turbines and two 11,000-kw Curtis turbines. Each of the Westinghouse turbines drives a twin generator, one 25-cycle, 6600-volt, and the other 60-cycle, 7500-volt. Either is used as required, they run at 750 r p.m. The main generating units are equipped with surface condensers, utilizing salt water from the East River for cooling. To provide against a shortage of coal in case of strike or delayed deliveries, the company has a storage yard at Shadyside, on the New Jersey shore, capable of holding 200,000 tons.

INTERBOROUGH RAPID TRANSIT CO.

This New York company also has an interesting history. It furnishes energy for both the subway and the elevated railway lines. The Fifty-ninth Street station, which carries the subway load, is of special interest in that it has five of the largest exhaust-steam turbines in existence. The original installation was completed about 1903 and contained nine 700-kw. Allis-Chalmers (combined double horizontal and vertical, 11,000-volt, 25-cycle). Later, about 1905, three 1725-kw. Westinghouse turbines were installed. Each of these engines had two horizontal high-pressure cylinders 44 in. diameter and two vertical low-pressure cylinders 88 in. diameter, with a common stroke of 60 in. The generators, of the flywheel type, are built of heavy steel plates.

The original boiler installation was fifty-two 600-hp. Babcock & Wilcox water-tube boilers, with space for 20 additional boilers. Eight more were eventually put in.; all are equipped with Roney stokers. Due to the rapid increase in the demand for electric current from this company, the capacity of the station had to be increased. Five low-pressure Curtis turbines of 7500-kw. capacity were installed between and to one side of the reciprocating engines without purchasing additional real estate.

The method used in starting up the combined engine generator and low-pressure turbine is simple and may be of interest. Excitation is applied before starting, then, when brought up to speed, the machine is synchronized in the usual manner. While starting in this way, the induction generator connected to the low-pressure turbine acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronous speed, when it immediately becomes a generator and picks up the load. The leads of the turbine are tied in solidly to the main generator leads through knife switches which are never opened.

The net results obtained by the installation of the low-pressure turbines in this station have been summarized as follows:

An increase of 100 per cent. in the maximum rating of the plant.
An increase of 146 per cent. in the economic output of the plant.
A saving of approximately 85 per cent. of the condensed steam for returns to the boiler.
An average improvement in economy of 13 per cent. over the best high-pressure turbine results.
An average improvement in economy of 25 per cent. (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.
An average unit thermal efficiency between the limits of 6500 and 15,000 kw. of 20.6 per cent.

In the Seventy-Fourth Street station there are 64 Babcock & Wilcox boilers and the generating equipment comprises eight Allis-Chalmers 7500-kw. combined horizontal and vertical Corliss engines, similar in all respects to the original installation in the Fifty-Ninth Street station and one 7500-kw. Westinghouse horizontal turbine of the same rating as the engines.

The growth of this company's business again required additional capacity from its generating stations and it has now decided to remove four of the engine units and install three Westinghouse turbines, each of 30,000-kw. capacity. These turbines are cross-compound units. The high-pressure element is a single-flow turbine operating between steam-boiler and [illegible] atmospheric pressure. On leaving the high-pressure cylinder, the steam goes through a receiver separator and then into the double-flow, low-pressure cylinder. The high-pressure end operates at 1500 r.p.m. and the low-pressure expansion end at 750 r.p.m.; both ends are controlled by a single governor driven from the high-pressure spindle. The two generators are electrically tied together, therefore, no governor is needed on the low-pressure end. The guaranteed water rate is 11.27 lb. per kw.-hr. Steam enters the center of the turbine through two openings and then divides, one half going each way to a condenser at each end of the turbine.

BROOKLYN EDISON SYSTEM

The tendency of the times is further emphasized by the case of the Edison Electric Illuminating Co., Brooklyn, which operates two main generating stations. Originally the Gold St. station was equipped with four 750-kw. engine-driven generators. At present there are four turbine units having a total generating capacity of 34,500 kw.

BOSTON EDISON

The Edison Electric Illuminating Co. of Boston operates the largest central-station plant and distributing system in New England, and supplies 31 cities and towns with electrical energy, serving an area of 466 square miles and a population of about 1,250,000. The point must remote from the main generating station is Hopkinson, 43 miles away.

The L St. plant consists essentially of two separate stations so far as the building and generating equipment are concerned. The two divisions of the plant are officially designated as Station 4-1 and Station 4-2, but they are electrically connected through suitable transforming and switching apparatus to serve the alternating-current system in common. The stations are radically different in type, representative of the state of the art at the periods of their respective construction. Station 4-1 contains 12 Babcock & Wilcox boilers rated at 550 hp. each, operated at 160-lb. steam pressure and supplying six 1500-kw., 60-cycle alternators directly connected to vertical cross-compound McIntosh & Seymour engines. All of the boilers in this station are equipped with Hawley down-draft furnaces and are hand fired. There is one stack 11 ft. 6 in. diameter and 225 ft. high.

Station 4-2 at present contains ninety-six 500-hp. boilers set in 12 rows of batteries. For the peak load in December, 1908, the available generating equipment in this station comprised four G. E. Curtis turbine units of 5000 kw. each, and one 8000-kw. unit of similar make. In 1909 two of the 5000-kw. units were replaced by 12,000-kw. sets, all of 60-cycle, 6900-volt design. The second pair were 7500 kw. each, the fifth unit 12,000 kw. and the sixth, seventh and eighth of 15,000 kw. each, making a total of 96,000 kw. The improved economy of the larger size and later design of turbine, combined with the modern practice of getting from 200 to 300 per cent. rating out of boilers at peak loads, enabled this increase in turbine capacity to be made without increasing the boiler capacity. The original design called for eight 500-hp. boilers to one 5000-kw. turbine, and there were eventually to be 12 of the 5000-kw. units.

Coal is removed from vessels by two movable steam hoisting towers to a belt conveyor running beneath them on the wharf, elevating it some 50 ft. and conveying it to the trestle alongside of the storage yard. Two traveling bridges, each having a large grab bucket, distribute the coal from the trestle to the yard, or reclaim it from the yard and deliver it to the belt conveyor system from the bunkers above the boilers. The conveyor system from the yard to the boiler house is in duplicate.

PHILADELPHIA ELECTRIC CO.

This company has two main generating plants, stations A-1 and A-2. Station A-1 is equipped with turbines varying in size from 7500 kw. to 15,000 kw. For this station a 35,000-kw. General Electric turbine is now being built. While it is 5000 kw. larger in capacity than the Westinghouse cross-compound turbine, it is contained in one unit and involves special characteristics recently developed by the General Electric Co. To permit of greater mechanical stability and to provide greater area in the low-pressure end, the casing is divided into two parts with a bearing between. The revolving field is an enormous steel forging, with milled slots, similar to small machines. The armature frame is cast in two halves, each of which represents about the limit of casting and transportation possibilities. The turbine and generator are mounted on a common base, thus constituting a single generating unit, in this respect surpassing anything else heretofore attempted.

WASHINGTON PLANT

The Bennings plant of the Potomac Electric Co. is on the Potomac River and supplies electric energy to the city of Washington, D. C. It is a modern and highly efficient all-turbine station of 37,000-kw. capacity, there being three 8000-kw. and two 5000-kw. units. All of the units generate 6600-volt, three-phase, 25-cycle current. The energy is transmitted underground to the company's substations.

In the boiler room there are twenty 600-hp. Babcock & Wilcox boilers and four 525-hp. boilers. Twenty of them are equipped with Roney stokers and four with Taylor stokers. This station was built in 1906 and thus far has had a successful existence. The station output has steadily increased from a little over 29,000,000 kw.-hr. in 1907 to 101,000,000 kw.-hr. in 1913; 44 per cent. of the station output is for lighting and the remainder for railway service.

PLANTS OF THE DETROIT EDISON CO.

Delray plants Nos. 1 and 2, are four miles southwest of the business center of Detroit, on the banks of the Detroit River. No. 1 station, built in 1904 and containing four 3000-kw. units, now has four 8000-kw. Curtis turbines. No. 2 station, built in 1908, has three 14,000-kw. and one 15,00-kw. turbines, making the turbine rating of the two plants 89,000 kw.

The output of the Delray plant is delivered for the most part to customers of the Edison Illuminating Co in Detroit, although an extensive suburban district is also supplied through the Eastern Michigan Edison Co. There is also a 50-mile transmission line connecting the station with the town of Memphis, Mich. About one-fifth of the station output is supplied to the Detroit United Railways Co.

The original design of the No. 1 plant included a surplus of boiler capacity for the purpose of permitting the four original 3000-kw. Curtis turbine sets to operate noncondensing. The exhaust steam was to be supplied to salt refiners in the vicinity for evaporating the brine. Twenty-four 500-hp. Stirling water-tube boilers were installed, set in four atteries of six each. Each boiler contains 4834 sq.ft. of heating surface. The second bank of tubes forms the superheater with an area of 1500 sq.ft. and superheating to 600 deg. F., or 200 deg. F. above the normal temperature of the steam at 210 lb. per sq.in.

The first four turbines in station No. 1 were run condensing. The plan for supplying exhaust steam to the salt refiners was never carried out because the company's load had so increased that it was found necessary to install an additional 3000-kw. unit; this was done without increasing the boiler equipment.

The first four 3000-kw. machines of 1904 were replaced in 1911 by 8000-kw. units of similar type; they were equipped with Worthington 16,000-sq.ft. surface condensers of the base type.

The No. 2 turbine room has three 14,000-kw. and one 15,000-kw. vertical Curtis General Electric turbine units, which, like the machines in No. 1 turbine room, furnish 4600-volt, 60-cycle, three-phase energy. The turbines are ventilated by forced draft and the dampers are so arranged that air can be taken from the engine room and delivered to the outside, or, as is desirable in winter, the outside air can be taken into the machines and delivered to the engine room.

Of special interest in connection with the Delray plants are the nine big double-fired Stirling boilers in No. 2 power house, each having a rated capacity of 2365 hp. The normal output is 7000 kw. in regular service and they have been drawn upon for 11,000 kw. during short periods. All are equipped with Taylor stokers, which have a nominal area of 300 sq.ft., with a heating-grate ratio of 79 to 1. The steam pressure carried in this plant is 205 lb., with 150 deg. superheat. This was one of the first stations to develop high superheat. The original steam fittings were cast iron and had to be changed to steel after five years, weakness in the iron having developed. The superheaters are mounted between the boiler tubes proper.

Each of the 54-in. steam drums has eight 4½-in. safety valves besides four 3-in. on the superheaters. The advantages in the use of these large units are found in a decreased cost per horsepower of rating; a lower radiation loss per unit of capacity, hence a higher efficiency, and they occupy smaller area per unit of output. Repairs on these larger units are not excessive and do not exceed the usual cost per horsepower with small-sized units. The combined boiler and furnace efficiencies obtained run from 80 per cent. at 75 per cent. rating to 76 per cent. at 200 per cent.

With the city's phenomenal growth and demand for electric energy, the Detroit company has under construction a 100,000-kw. plant at Connor's Creek, which is at the opposite end of the city. This plant is expected to be completed to take the fall load of 1915.

PLANTS OF THE COMMONWEALTH EDISON CO.

By far the greater part of the electrical energy generated by the Commonwealth Edison Co., in Chicago, is produced at the Fisk St. and Quarry St. stations, which are on the south branch of the Chicago River. The engine room of the Fisk St. plant is 630 ft. long and was originally designed for fourteen 5000-kw., vertical Curtis turbine units. The first unit was installed in 1903, but later it was decided to use 12,000-kw. units instead of 5000. One of the 12,000-kw. units had been installed when the advance in the art led the company officials to decide that the last four units should be of 20,000-kw. capacity, or larger, and of the horizontal type. Of these, two are already installed, one a General Electric 20,000-kw. and the other a Parsons 25,000-kw. turbine.

The boiler house of the Fisk St. station was originally designed for 14 batteries of eight 500-hp. boilers, and 10 of these batteries, comprising 80 boilers, are already in use. The remainder of the boiler house will be filled with four batteries, each of four boilers and each boiler having 12,250 sq.ft. of heating surface, with an equipment of economizers and induced draft fans with which, it is anticipated, the boilers can be worked at 200 per cent. of rating. The combined generating capacity of all the units at Fisk St. is 165,000 kw. When running at full capacity the station will consume nearly 2000 tons of coal a day, and nearly 200 tons during the maximum or peak hour. The number of heat units required to generate a kilowatt-hour with the old equipment was approximately 28,000; with the new equipment it is something less than 20,000. This would be two pounds of coal at 10,000 B.t.u. or 1.43 lb. at 14,000 B.t.u.

The great increase in the business of the Commonwealth Edison Co. made it necessary to build the Quarry St. station in 1908. The two stations are operated together as one electrical generating station, being connected by tie lines in two tunnels.

Arranged in two rows parallel to the turbine room are eight 500-hp. water-tube boilers for each generating unit, or 48 for the entire station. The original boiler setting at Quarry St. was a departure in furnace design in that the furnaces were placed under what is usually considered the rear header. In other words, the slope of the tubes was up and away from the furnace rather than the reverse. The advantage sought was in the long combustion chamber, expanding in volume, which made for more complete combustion of the fuel and an increase in boiler efficiency. These boilers were equipped with horizontal passes. After a time it was found that the maintenance costs were running high, and it was decided to equip the last six of the boilers with standard settings, although at the same height as the other; this gave a larger combustion chamber than is the usual practice. The station has eight 12-ft. steel stacks, 250 ft. high, each stack serving six boilers.

Eight boilers are independently connected to each of the six turbines, although cross connections are available in case of emergency. Each of the turbines has its own independent auxiliaries, including a hotwell pump, a combined circulating and vacuum pump, a feed-water heater and a 4-in. three-stage centrifugal feed pump. Quarry St. was the first station in the United States to install centrifugal boiler feed pumps.

The rate at which the business of the Commonwealth Edison Co. was increasing made it evident in 1910 that the Fisk and Quarry St. stations would be inadequate for the service and plans were immediately made for additional station equipment. The new Northwest Station has been the result. Between 1908 and 1910 the maximum load on the system grew from 117,370 kw. to 182,600 kw., an increase of 55½ per cent. In 1912 the maximum load had further increased to 200,000 kw. In planning for the capacity of the new station the indications were that for a number of years the increase would average at the rate of 15 per cent. per year. This rate of increase, applied to the load of 200,000 kw. in 1912, indicated that the net increase of load during the following five-year period would amount to 220,000 kw. Accordingly, plans were made for two new power houses of 220,000 kw. each, it being considered advisable to prepare for more than five years' growth. A location was therefore selected which would be suited to the many and great requirements of such an equipment. To supply fuel for an aggregate of 240,000 kw., or 350,000 hp., requires something like 4000 tons of coal per day, or 100 car loads. Inasmuch as the fuel has to be brought 200 miles by rail for the Chicago plants, a reserve supply of even four days, if held in cars, would mean four miles of track room for 400 cars. The coal strikes, which occur quite regularly every two years, however, frequently mean that no coal can be had from the mines for three months. Hence one of the demands of the new plant was that there must be sufficient storage for coal to carry the stations over a three months' interval— that is, storage room for 350,000 tons. The site of the new Northwest station was therefore chosen at a point on the north branch of the Chicago River, several miles from the Fisk and Quarry St. stations, where sufficient acreage for coal storage was available.

The boiler house is so designed and equipped that at no point in the handling of the great volume of coal that daily passes through it, is it necessary to use manual labor. The boilers are arranged in rows of ten each, facing each other on opposite sides of a common firing aisle, so that one set of firemen and water tenders can look after twenty boilers. Each ten boilers are served by a tile-lined steel stack, 17 ft. inside diameter and extending 275 ft. above the boiler-room floor. When completed the turbine room will be 290 ft. long with the five turbines spaced on 44-ft. centers. The first two turbines are of the vertical Curtis type, similar to those at the Fisk and Quarry St. stations, and are rated at 20,000-kw. capacity, with a steam consumption of 13.45 lb. per kw.-hr. at the most efficient load, namely, 15,000 kw. The additional units for this plant are expected to be of the horizontal type and may run in capacity to 30,000 kw. or more.

COMMERCE STREET STATION, MILWAUKEE

The generating capacity of this station is 61,900 kw. The development of the plant has been in three periods. The first installation was in 1902 and consisted of four 1500-kw., engine-driven, 25-cycle units equipped with barometric condensers and eight 650-hp. boilers equipped with Jones underfeed stokers.

In 1905 four more engines were added, driving 2000-kw.: 600-volt, direct-current generators, and eight additional 708-hp. boilers. Shortly after this two 1000-kw., 60-cycle vertical General Electric turbo-generators were installed. In 1911 the final additions were made which have brought the plant into practically its present condition. At this time all of the barometric condensers of the original installation were removed and the two 1000-kw. turbines taken out.

For increasing the capacity of the plant two 7500-kw., low-pressure, 25-cycle turbines were added to operate in series with the reciprocating engines, similar to the installation in New York, and also two high-pressure, 14,000-kw., 60-cycle vertical turbines. Along with this increased generator capacity eight additional 765-hp. boilers and auxiliaries were installed. Since then a 4500-kw. 60-cycle turbine has been put in.

The steam supply for the low-pressure turbine in this station is taken from the exhaust of seven reciprocating engines, all exhausting into a common header and supplying steam to the turbines at 16 lb. initial pressure. The receiver separator taking the steam from the engines is the largest steam separator in the world, being 10 ft. in diameter and 22 ft. high.

The effect upon the steam economy of the installation of low-pressure turbines was marked. It was estimated that about one kilowatt-hour of energy could be obtained from the low-pressure turbine by the use of steam exhausted from the engine while delivering one kilowatt-hour, thus getting two kilowatt-hours of energy for the water rate of one kilowatt-hour on the engines noncondensing. The latter rate was about 30 per cent. higher than under condensing conditions. The overall water rate would thus be changed in about the ratio of 22 to 16 lb. per kw.-hr.

The total rated capacity of the 24 boilers in the Commerce St. station is 16,984 hp., or one boiler horsepower for each 3.64 kw. of installed capacity. Operating conditions, however, are in the ratio of one boiler horsepower for each 1½ kw. of installed capacity. There are 12 stacks, each 8 ft. in diameter and 100 ft. high, each of which serves two boilers.

ST. LOUIS PLANT

There are few plants throughout the country that show development more clearly than does the Ashley St. station of the Union Electric Light & Power Co. The original units were 3000-kw. Allis reciprocating engines. These units are still in place, but are utilized for emergency operation only. Next came the 5000-kw. turbine units which were replaced by the 12,000-kw. Curtis turbines. Four of these units were installed upon the same foundations and with the same auxiliary equipment that had been used for the 5000-kw. turbines. This change increased the generating capacity of the station from 36,000 kw. to 64,000 kw., an increase of 78 per cent., and at the same time reduced the steam consumption on the turbine generating units from 21 to 15½ lb. per kw.-hr., a reduction of 26.2 per cent. Subsequently, two 2000-kw. vertical Curtis turbines were replaced by two 4000-kw. horizontal Curtis turbines.

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Preserve Original Trial Data—On installing new machinery, the results of the initial trials should be recorded and filed for reference. Duplicate copies of these results should also be made. It is of value to know the conditions under which a boiler, engine, pump or other apparatus worked when new, for comparison with later tests and trials

Prize-Winning Regulating Device

Our readers will recollect the photographic contest inaugurated in July by the Mason Regulator Co., and which closed Nov. 2. The aim was to obtain photographs and data of its devices which were performing some unusual duty. The following have been announced as winners of the $25, $15, $10 and two $5 cash prizes, respectively:

H. N. Downs, Shelton, Conn.; George Van Vleck, Rochester, N. Y.; W. H. Odell, Yonkers, N. Y.; C. Cooper, Portland, Ore., and A. H. Cutler, Putnam, Conn. Ovide Vachon, Beauport, Que., Can., received a special prize of $10, he having submitted a drawing which debarred him from the photographic contest.

The judges were F. L. Fairbanks, chief engineer, Quincy Market Cold Storage & Warehouse Co., Boston; E. H. Kearney, past-president, National Association of Stationary Engineers, and Albert C. Ashton, treasurer of the Ashton Valve Co., Boston, Mass.

The winner of the first prize, H. N. Downs, is employed as an operating engineer at the plant of the Sidney Blumenthal Co., Shelton, Conn. The arrangement which captured the largest prize money consisted of a Mason steam pump speed governor mounted on an 18 and 16 by 24-in. double-acting Davidson pump (Fig. 1), which supplies water to a gravity tank located approximately 20 ft. above the ground level. Before entering the tank the water is forced through two Roberts pressure filters, connected in multiple, and having a capacity of 1,000,000 gal. per 24 hr.; the water is used for dye-house purposes.

The pump is controlled by the speed regulator so as to avoid forcing the filters in case of variable steam pressure. In series with the balanced valve used wtih a speed governor is a second balanced valve, operated by a float in the tank (Fig. 2). The tank is 16 ft. high and the float is set so that it does not begin to operate until there is 12 ft. of water in the tank, when the balanced valve A is gradually closed by the action of the float, thus partially shutting off the steam supply to the pump, and making the filter plant prac-

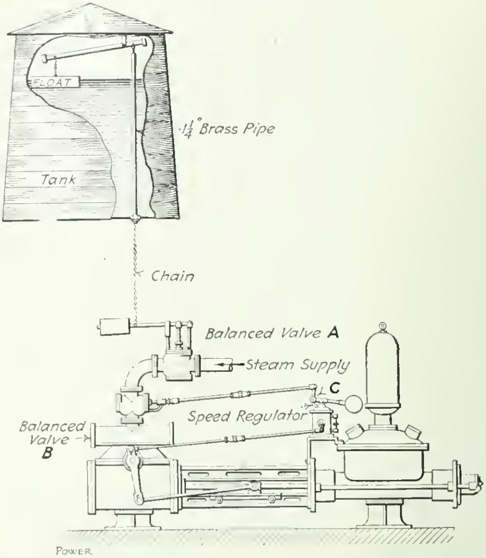

Fig. 2. Showing Arrangement of Speed Regulator and Balanced Valves, the Top One Being Controlled by the Tank Float

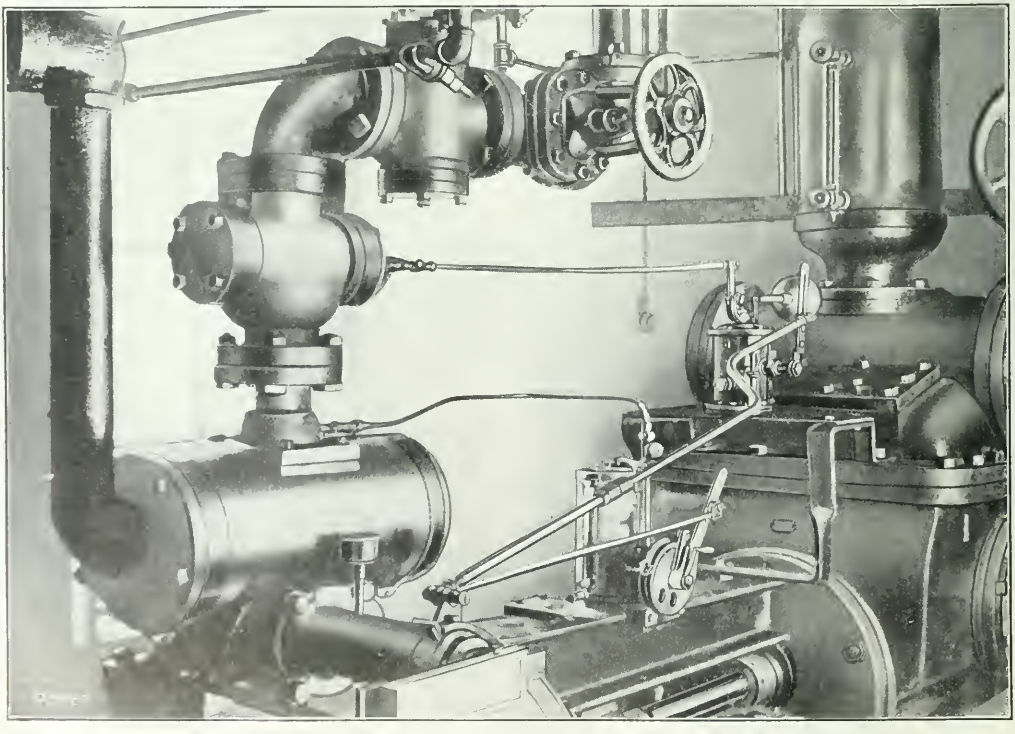

Fig. 1. Illustrating the Apparatus Which Won the First Prize in the Photographic Contest

tically automatic in operation. When the water level reaches a height of 15 ft. in the tank the steam is shut off. For the float a small gasoline tank was used, and to assure positive action the float lever has a ratio of approximately 10 to 1.

When the speed governor was first installed some trouble was experienced because the float-operated valve would open as the tank emptied, allowing the steam pressure to act on the piston of the pump, causing it to race until the speed governor gathered sufficient oil pressure to build up and govern the pump. This was overcome by putting on an adjustable bracket under the lever which holds it up in practically its operating position, and thus allows the pump to accelerate properly.

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Flywheel Explosion at Iola, Kan.

On Oct. 27, at about 1:30 p.m., the flywheel of a 400-hp. engine exploded at a plant where about five hundred men were employed. The explosion threw pieces of the wheel over 1000 ft. away, wrecked one corner of the engine room and left nothing but the hub and a part of one spoke on the shaft.

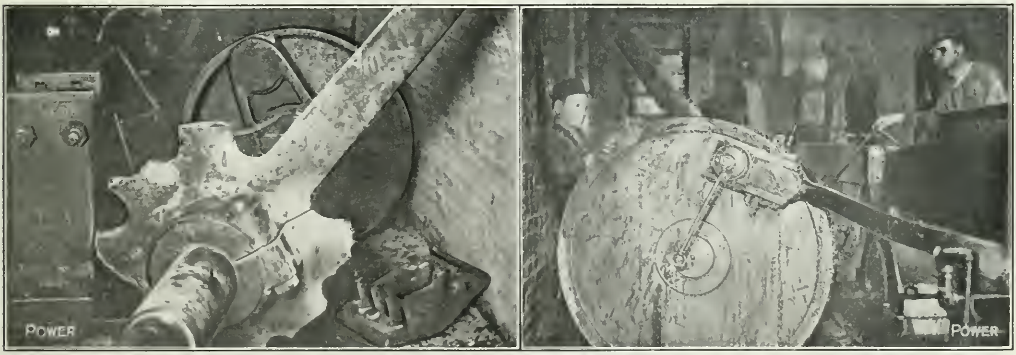
The cause of the accident was overloading the 34-in. three-ply leather belt driving the lineshaft, it being broken in several pieces.

The cast-iron flywheel weighed six tons and was 14 ft. in diameter and had a 36-in. face. It was cast in two parts and bolted at the hub and rim; all of the bolts held. The wheel ran normally at 105 r.p.m.

The largest piece weighed about three hundred pounds. A 215-lb. piece was thrown over the rock bins and landed on the laboratory building. Other parts were scattered over the factory grounds and buildings. The driven and tightener pulleys were broken in small bits.

The illustrations show the hub, shaft and disk, also the bent connecting rod. These parts weighed about four tons and were thrown against the wall. The 400-lb. cylinder head was blown forty feet away and against the rear wall.

Although eight men were in the engine room at the time, exclusive of the 500 men about the plant, no one was hurt.



RESULT OF A FLYWHEEL EXPLOSION

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Effect of Washing Kansas Coal

Before the Kansas Gas, Water, Electric Light and Street Railway Association, A. A. Potter, dean of the division of engineering and professor of steam and gas engineering at the Kansas State Agricultural College, read a paper on the above subject. The results, as expressed in the paper, are briefly given in the following:

The coal was washed to remove the clinker formative impurities. This was accomplished by running the coal through a washer or tank filled with water. The water in the tank was given a pulsating motion, forcing the coal to the surface and allowing it to be carried away by the water. The impurities, which were heavier than the coal, settled, and were removed by a conveyor.

To determine the effect of washing Kansas coal, three representative carloads of coal were selected at the mines of the Kansas state penitentiary at Lansing, Kan. Samples of the coal for chemical analyses were taken at the mine and at the cars. One of these test cars was sent to Manhattan, Kan., as mine-run coal and boiler tests were conducted with it at the engineering laboratories of the Kansas State Agricultural College, using hand-fired as well as stoker-fired boilers. The second test carload of coal was crushed and then tested at the college in a similar manner. The third carload was also crushed and washed at the washery of the Central Coal & Coke Co. The washed coal was then tested at the college.

EFFECT OF WASHING ON CHEMICAL COMPOSITION

1. The ash and other noncombustible material was decreased 45.8 per cent.
2. The sulphur in the coal was decreased by 50.1 per cent.
3. The fixed carbon was increased by 7.3 per cent.
4. The heat of combustion per pound of fuel was increased about 22 per cent.

EFFECT OF WASHING ON BOILER OPERATION

1. The total ashes handled in the case of washed coal was 22.7 per cent. less than in the unwashed, all other conditions being the same.
2. The evaporation of the boiler in pounds of steam per hour from and at 212 deg. F. was increased by 23.6 per cent.
3. The evaporation of the boiler per square foot of heating surface was increased by about 20 per cent.
4. The capacity of the boiler in boiler horsepower was increased by 20 per cent.
5. The total efficiency of the boiler, furnace and grate was increased 10.7 per cent.

During the tests it was evident that the firemen had much less difficulty in keeping up the steam pressure with the washed than with the unwashed coal. The reduction in the sulphur eliminated the formation of bad clinkers and decreased the frequency and labor of cleaning fires.

In general, the results of both the chemical and the boiler tests showed that considerable saving can be effected by washing coal if the coal contains much clinker formative material.

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Electricity in Manufacturing

"Electricity in Manufacturing" was the subject discussed at the recent meeting of the New Haven Section of the American Society of Mechanical Engineers. The first speaker, Prof. C. F. Scott, pointed out that industry is essentially the transformation of materials from the raw state to a useful product which involves the combined efforts of labor and power. Industry in its beginning employed human labor entirely, which was later replaced by the engine and an endless array of belts and shafting. Present industry replaces these with a new link between the engines and the actual working machines, namely, the dynamo, with ramifying wires to motors of all descriptions. This not only replaces but adds to the variety of operations and use of power. Thus there are electroplating baths, electric furnaces, hoists, magnets and factory and office lighting, all of which are obtainable from the same source.

A review of the industries of the United States since 1870 shows the population to have doubled in about thirty-three years, the value of manufacturing products in sixteen, the horsepower used in even less, while since 1890 the electrical horsepower has increased by leaps and bounds, doubling in three or four years.

Locally, Connecticut has a number of companies operatin central stations which furnish power to manufacturers. Of this power, a large amount is alternating current, testifying to its utility in operating machinery. These companies are rapidly replacing steam units, the average motor sizes running from 10 to 25 hp., with a maximum of 250. The central station, which makes a specialty of generating power, in Professor Scott's opinion, is often able to do this much more cheaply than individual manufacturers, and at the same time will save the latter the bother incident to looking after their own plants.

If the relative costs of material, labor and power are compared, it will be found that material and labor are usually of the same magnitude, whereas the power item is relatively small. Taking the labor cost for one day, the corresponding power cost is equal to the labor cost of half an hour, the light bill to that of five minutes, and the interest on the money invested in the motor, and repairs, to that of one minute.

The power cost proving to be relatively small, the aim of the manufacturer should not be essentially to save power, but to utilize it to the highest degree possible to do part of the work which labor at present must perform, or, by time-saving applications, to make that labor more efficient and increase the production or quality. It may also effect a saving in the material used, by improved methods or processes or by certainty of operation. "Its very flexibility and adaptability," said Professor Scott, "must make electricity a valuable agent in transforming materials."

W. L. Merrill, of the General Electric Co., next presented an illustrated lecture on "Mechanical Methods of Motor Application," the underlying argument being that the manufacturer of a product must coöperate with the electrical manufacturers, and both of these with the builders of machinery used in the industry. With regard to individual drive, he pointed out that simplicity and the elimination of duplicate parts for producing a given operation are necessary for its perfection. As a rule, the more direct and closer the motor, the greater the efficiency. Many slides were shown to emphasize where and where not to put motor drives. In particular, high overhung motors are undesirable as is also any location leading to much vibration.

In the discussion following, Mr. Flynn, of Hartford, told of using electricity in bake ovens for typewriter machines after japanning. Electricity, purchased from the Hartford Electric Light Co. at the extremely low price of 0.9 cent per kw.-hr. was responsible for a saving of 10 per cent. per machine baked with much greater certainty of the result.

Other points emphasized in the discussion were, that, with electricity, to pull the switch is to cut off the expenditure at once; that the flywheel inertia of pulleys, shafting and belts is often needed, but is many times forgotten in applying motors; that with motors directly applied, quick starting and stopping sometimes cause considerable strain on shafts and bearings in view of which the question was raised as to whether a belt is not sometimes good in the capacity of a safety valve.

At the evening session S. J. Morgan, of Boston, read a paper on "The Electric Motor in Manufacturing Plants," pointing out that the keynote of progress is time, or rather the intensified use of time, for in progressive manufacturing it is necessary to use every second out of the sixty and that at maximum speed. For example, the cutting time on many machines is only one-third of the total used on a piece, the balance being consumed in making adjustments; consequently the cutting time must be used at maximum efficiency.

The speaker next considered various styles of drives, recommending in general the individual drive. This may be more expensive in some cases but the extra cost may be paid in a comparatively short time by the saving in power and friction load.

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Damages for Loss of Water Power

In a paper before the American Society of Mechanical Engineers, F. W. Dean, of Boston, discussed the subject of damages for loss of water power when a stream is diverted and suit is instituted by mill owners whose plants are located below the point of diversion. In such cases the value of the water power diverted is generally determined by the cost of making the power by steam, the actual value being the capitalization of the saving effected by the use of water.

On the one hand, power can be produced by a steam plant, and on the other, by water power combined with steam to produce a uniform supply throughout the year. If the annual charges (fixed and operating) of the steam plant exceed those of the water plant and auxiliary steam plant combined, the water power has value, but if less it has no value.

The theory in a suit of this kind is that the award shall be such that the interest thereof shall be sufficient to equal the extra expense caused by the diversion. This rate is usually taken as 5 per cent., although this is often the subject of argument.

As pointed out by Mr. Dean, water powers are seldom developed to the full capacity of the wet months, it being customary to develop to the average power of the eighth or ninth month of the year, when the stream flows are arranged in the order of wetness. In this connection it might be remarked that the calendar order is without significance.

A water power produced by the unassisted flow of a stream is of little value when developed to the customary extent. It frequently happens, however, that areas are available in the watershed that can be dammed, and overflowed in the wet months so as to be used to make up to some extent the deficiency in the drier season. This is usually done, and is a saving feature of water-power development, but it probably in no case results in a uniform power supply. In such developments as those at Niagara and Keokuk, steam plants are not necessary because the power required for a long time will be below the minimum flow, and especially at Niagara, which for scenic reasons will probably never be developed to use the minimum flow.

AUXILIARY STEAM UNITS

The most economical engine to install depends upon the power to be made up to produce a steady supply. Between certain limits, the author expressed the belief that the simple non-condensing type was the most economical. Beyond this, and up to a certain other power, the simple condensing engine should be used, and still further the compound condensing engine if necessary. Similar arguments apply to condensing and non-condensing steam turbines. The points to be considered are those producing the greatest net economy as made up of fixed charges and costs of operation. In every case, an engine should be selected that will be well overloaded in the driest average month and much underloaded in the wetter months; and the requirement of the months of the driest year should also be considered.

In damage cases much testimony is given concerning the economy of steam plants. It is well known that such economies are variable and differ from one another. In some cases good plants are carefully operated, while in others they are neglected and incompetent men are employed, but the latter should not be taken as criteria for basing an award for damages.

It often happens that the power to be made up through the diversion of the stream is sufficiently small to be assumed by the existing engine. Of course, if this cannot carry the additional load another should be added, but if an expert seeks only to obtain the highest award for his client he will probably advocate an additional engine. The same remarks apply to boilers.

EFFICIENCY OF WATER WHEELS

The maximum efficiency of water wheels which are new and clean has been found to be nearly 85 per cent. Wheels are generally so made that the maximum efficiency is at 70 to 85 per cent. gate opening on account of the probability that the gate will not be wide open, as a general thing. Moreover, it is impossible to keep the wheels clean as they become rusty, coated with dirt and more or less clogged with débris. As the supply of water is variable and small at times, the usual position of the gate is likely to be at such a point that the average efficiency will not be over 75 per cent. The gate opening which corresponds to this efficiency is from 45 to 55 per cent.

Testimony is often given to the effect that the average efficiency of water wheels is as much as 80 per cent., and this is used in estimating the power loss, while an examination of efficiency curves and contemplation of conditions to which the wheels are subject will show that such an efficiency under the conditions is impossible.

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Wood Pipe for Conveying Water—"How long will it last?" is a question asked perhaps more than any other concerning the use of wood pipe for irrigation. That the life of such wood pipe should be at least 20 years if the pipes are fully exposed and supported free from all contact with the soil; if the material is either fir or redwood; and if the pipe has been properly maintained, is the conclusion of a specialist of the U. S. Department of Agriculture in a professional paper on "Wood Pipe for Conveying Water for Irrigation" (Bulletin No. 155). Irrigation engineers and the owners of irrigation works will be particularly interested in this new pamphlet, which may be had free of charge by applying to the Department of Agriculture, Washington, D. C.

ENGINEERING AFFAIRS

Mountain States Ice Manufacturers Association—The second annual meeting of the Mountain States Ice Manufacturers Association will be held at the Albany Hotel, Denver, Colo., Thursday, Friday and Saturday, Jan. 21, 22 and 23, 1915. James F. Vandewark, Fort Collins, Colo., is secretary.

Y. M. C. A. School in Refrigeration—The West Side Y. M. C. A., 318 West 57th St., New York City, has decided to offer courses of instruction in refrigerating engineering. The special aim of these courses will be to meet the special requirements of the operating engineer, but if the demand warrants it, design courses will be included. Evening classes will be offered for engineers working during the day and day classes for men working at night. Prof. R. L. Shipman, recently of Cornell University, who has an extensive experience as operating engineer, will act as director of these courses.

PERSONALS

F. L. Bunton, for the past two and one-half years manager of the Chicago office of the Heine Boiler Co., is now manager of the Chicago office of the Goulds Manufacturing Co., 3801-3811 South Ashland Ave., Chicago, Ill.

Nicholas S. Hill, Jr., consulting hydraulic and sanitary engineer, 100 William Street, New York, has formed a partnership with Smith Farley Ferguson, and will continue to practice with him under the firm name of Nicholas S. Hill, Jr. and S. F. Ferguson. Mr. Ferguson will assume charge of the office management and the finances and accounts of the firm, as well as of the awarding of contracts and of the ordering, inspection and delivery of materials for construction work and contribute his experience in the design, erection and operation of steam power plants. For a number of years past he was president of Mackenzie, Quarrier & Ferguson, Inc., contracting and construction engineers.

Byron T. Burt has tendered his resignation to take effect Jan. 1, as general manager of the Chattanooga & Tennessee River Power Co., and he will be succeeded by George S. Baker, who has been auditor of the company. Mr. Burt will go to Buenos Aires early in the year as manager of the South American Trading Co., and will open the main office of that concern for the sale of American manufactures in Argentina. He was manager of the old Chattanooga Electric Co. until its consolidation with the Chattanooga Railway & Light Co. When the Chattanooga & Tennessee River Power Co. was organized to construct the power plant at Hale's Bar on the Tennessee River, he was made general manager. He is an electrical engineer and member of several national scientific organizations.

OBITUARY

COLONEL E. D. MEIER

Col. Edward Daniel Meier, eminent engineer and manufacturer, died at the home of his daughter in New York City, Dec. 15, in his 74th year The immediate cause of death was heart failure and hardening of the arteries. Ill health had kept him from active participation in business for over a year. The funeral services were held from his home in St. Louis, Dec. 17.

Colonel Meier was born May 30, 1841, in St. Louis, Mo., the son of Adolphus Meier, a prominent industrialist.

After a scientific course in Washington University, St. Louis, young Meier studied for four years at the Royal Polytechnic School, Hanover, Germany. In 1862 he started as an apprentice at the William Mason Machine Works, Taunton, Mass., but soon entered the army. Here he served in an engineering capacity and had the honor to receive the surrender of Lieutenant-General Hood. His colonelcy was acquired in the Missouri National Guard, following his activity in the railroad riots of 1877. He declined a commission as brigadier-general.

After the war Colonel Meier was for a year connected with the Rogers Locomotive Works, Paterson, N. J., and in 1867 was made assistant division superintendent on the Kansas Pacific R.R., later becoming superintendent of machinery. After his resignation in 1871, due to ill-health, he took an active part in various industrial enterprises, such as the coking of Big Muddy coals and the smelting of Iron Mountain ores. He was chief engineer of the Illinois Patent Coke Co. In 1872 he was manager of the Meier Iron Co. and built its blast furnaces. From 1873 to 1875 he directed the machinery department of the St. Louis Interstate Fair. During this time he was actively interested in the St. Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press.

About 1884 Colonel Meier organized the Heine Safety Boiler Co. for the development in the United States of the water-tube boiler of that name, and was its president and chief engineer until his death. He was also responsible for the introduction of the Diesel motor into the United States. He visited Germany in 1897 to investigate it, and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Co.

Colonel Meier was active in a number of professional organizations. From 1881 to 1884 he was treasurer of the St. Louis Engineers' Club and president from 1889 to 1890. During the latter period he was also secretary of the American Boiler Manufacturers' Association. As chairman of the committee on materials, he is largely to be credited with both the first and second sets of standard specifications. In 1908 to 1909 he was president of the association and also of the Machinery and Metal Trades Association

Colonel E. D. Meier

In the American Society of Mechanical Engineers, Colonel Meier was active on many committees and was twice its vice-president, serving his first term from 1898 to 1900, and beginning the second in 1910. He was elected president of the society for the year 1911.

As the seventieth birthday of Colonel Meier, retiring president of the society, occurred on Memorial Day, 1911, during the Pittsburgh meeting, a large number of the members united in a subscription and presented him an illuminated address of congratulation, and also asked his consent to give sittings for a portrait. The artist was Daniel J Strain, vice-president of the Boston Art Club

CHARLES A. MOORE

Charles A. Moore, president of Manning, Maxwell & Moore and a well known personality in the engineering supplies business, died of heart failure, on Dec. 9, on the Holland-American liner "Rotterdam" bound for Italy. Mrs. Moore was with him on the trip. Mr. Moore's health has been failing for the last few years and he has not actively managed the business during this time.

Mr. Moore was born in West Sparta, N. Y., in 1846 and was orphaned at the age of ten. He served in the Navy during the Civil War, after which he returned to Lynn, where he had been caring for an uncle.

In 1873, when the Ashcroft Manufacturing Co. was but a small hardware concern, Mr. Moore interested himself in the company and gave it considerable assistance. It was not long until Mr. Moore was active in several companies in New England, and his ability as a salesman and an organizer led him to create a world-wide selling organization devoted chiefly to steam specialties. In 1880 he came to New York and was active in forming the company of Manning, Maxwell & Moore. Late in the eighties Mr. Maxwell died and in 1905 Mr. Manning retired, Mr. Moore purchasing his share.

Mr. Moore was a member of the American Society of Mechanical Engineers and was for a long time a conspicuous figure in the Republican party. He was a noted Protectionist and was for some years president of the American Protective Tariff League. President McKinley and he were close friends, Mr. Moore accompanying him on several pleasure and campaign trips.

Charles A. Moore

Mr. Moore was identified with the Shaw Electric Crane Co., the Consolidated Safety Valve Co., the Ashcroft Manufacturing Co., the Hancock Inspirator Co., and the United Injector Co.

CHARLES A. HOPPER

The announcement of the death of Charles A. Hopper, of the Keystone Lubricating Co., of Philadelphia, which occurred on Nov. 29, will be received by his host of friends with keen sorrow.

"Charley" Hopper was possessed of those characteristics which radiated good nature and unconsciously left their imprint upon those fortunate enough to know him. He was broad minded, capable and endeared himself to all.

He became associated with the Keystone Lubricating Co. soon after its organization by A. C. Buzby, the present general manager, and together they labored zealously to bring it to its present-day success. Being closely associated, it was but natural that Charley's opinion and judgment should be courted, and the loss created by his death seems irreparable.

Having a capacity for administrative salesmanship, he took up that department of the business which included steam engineering, power plants and mills. He was remarkably successful along these lines, and was personally known to many identified with these industries. Most of these acquaintances became fast friends and will mourn his death. Having reached an age which brought with it wide experience, much knowledge and an appreciation of life's demands, it was expected by those associated with him in his work that many years of usefulness would be his lot. Realization of the loss of a friend will be more poignant to those who will miss daily his inspiring presence.

"Charley" Hopper

He was a member of the National Association of Stationary Engineers and various societies, among them the Red Men, I. O. of A. and the A. O. U. W.

BUSINESS ITEMS

The Jeffery-Griner Machinery Co., Bourse Building, Philadelphia, Penn., has completed arrangements for handling the Neemes Bros. (Troy, N. Y.) grates in the Philadelphia territory.

J. H. Dougherty, formerly with the Engineering Department of the Jeanesville Iron Works, of Hazleton, Penn., has joined the staff of the Northern Equipment Co., Erie, Penn., in the capacity of designing engineer.

In order to properly handle business in the central district, the Power Specialty Co., 111 Broadway, New York, has found it necessary to move its Chicago office from Peoples Gas Building into more commodious quarters in the Harris Trust Building.

Betson Plastic Fire Brick Co., Rome, N. Y., is moving into a much larger plant, with increased facilities, in order to take care of its continually growing business, and after Dec. 1 will be located at 244-246 E. Dominick St., Rome, N. Y. The post office address is box 372.

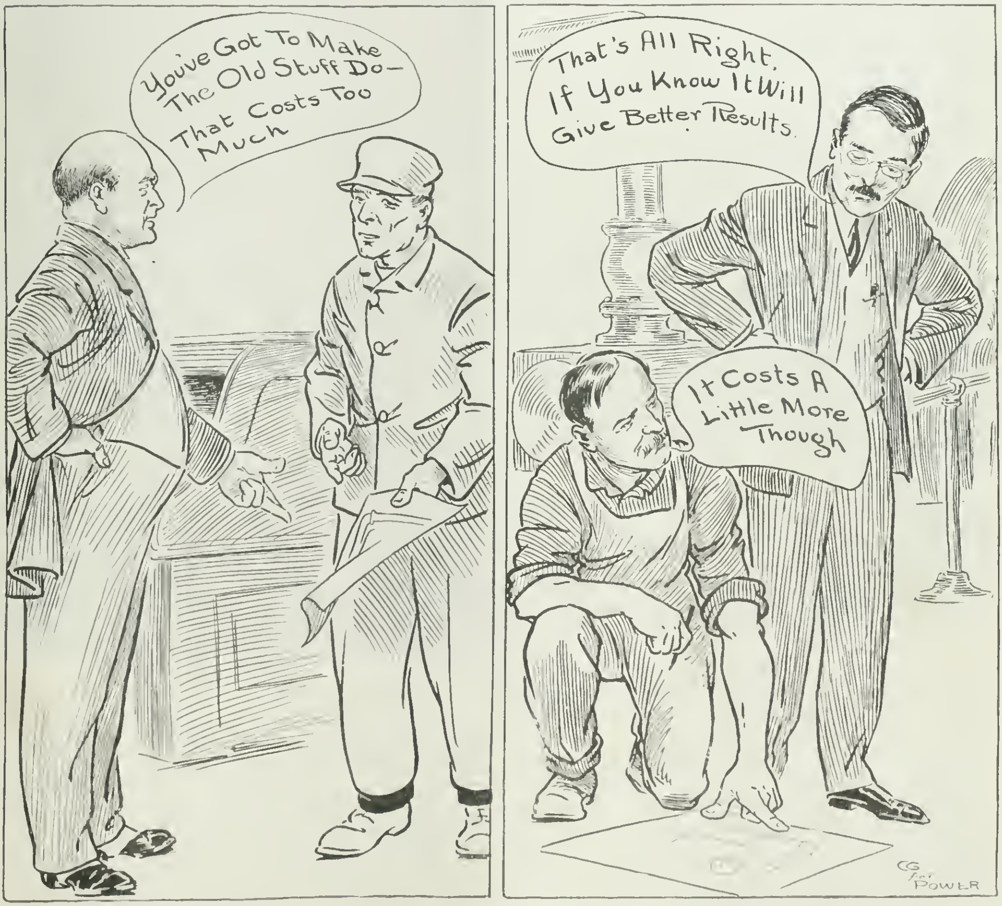
Orr & Sembower, Inc., Reading, Penn., manufacturers of vertical, horizontal, marine and hoisting steam engines, vertical, horizontal and locomotive boilers and vertical, horizontal and hoisting gasoline engines, have opened a permanent exhibition in the Bourse, Philadelphia, Penn.

The Hunter Fan & Motor Co., of Fulton, N. Y., has sold its controlling interest in the Kitts Manufacturing Co., Oswego, N. Y., to Marvin E. King and James Parker, manager and superintendent of the Kitts Manufacturing Co. Messrs. King and Parker will continue along the same lines of manufacturing and will broaden the line to the extent of vacuum heating engineering work.

The Stephens-Adamson Manufacturing Co., Aurora, Ill., is changing the electrical equipment throughout its shops, using individual motors and group drives. Tests have been made on all machines, and the results assure a considerable saving in power cost. Plans are also being prepared for another structural steel shop; construction of the same to be begun immediately after the first of the year. This will be the eighth building of the company's plant. This company reports a very satisfactory increase in its business during the present year and a most encouraging outlook.

POWER

Vol. 40 NEW YORK, DECEMBER 29, 1914 No. 26


You've Got To Make The Old Stuff Do— That Costs Too Much
That's All Right, If You Know It Will Give Better Results.
It Costs A Little More Though
CG for POWER

ONE REASON WHY SOME PLANTS ARE MORE EFFICIENT THAN OTHERS

Power Plant of the Acme Tea Company

SYNOPSIS—In designing the power plant of the new bakery for the Acme Tea Co., Philadelphia, Penn., the primary objects were efficiency and provision against interruption to the bread-making process by failure of the power supply; the doughs must be worked within a comparatively short time. Any failure in the daily supply of bread and cake is a loss to over 250 company stores.

◆

Practically three sources of power supply have been provided for the new bakery of the Acme Tea Co., at 25th, York and Hagert Sts., Philadelphia, Penn., two being obtained by duplicate boilers, engines and generators, and the third by an emergency service connection with the street mains of the Philadelphia Electric Co.

The steam plant is in the basement at the Hagert St. end of the main building, Fig. 1, and is so isolated as to prevent dust from coal or ashes reaching the interior of the building.

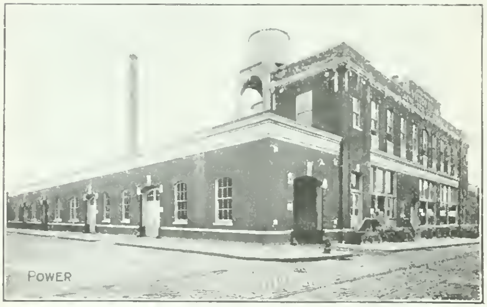


Fig. 1. Bakery of the Acme Tea Co.

For the steam supply, there are two 270-hp. down-flow water-tube boilers, Fig. 2, the furnaces of which are equipped with shaking grates. Draft is provided by a radial brick chimney having an inside diameter of 54 in. at the top and a height from the boiler-room floor of 127 ft. 10 in.

Electrical power is used in the plant, except in a few instances, and is applied by individual motors for each machine wherever possible, shafting being practically eliminated. An alternating-current, 220-volt, two-phase, 60-cycle, four-wire system is used so as to switch to the break-down service without intermediary apparatus. This 220-volt current also permits the use of squirrel-cage motors, which are particularly suitable for the service because of the flour dust. The break-down service enters the building underground and is connected to independent busbars on the main switchboard; its capacity is equal to either of the two generating units.

Generating Units

For generating electrical energy there are two horizontal, center-crank, tandem-compound, direct-connected engines, with 13½-in. diameter high-pressure and 20½-in. diameter low-pressure cylinders, 16-in. stroke, running at 225 r.p.m. These engines are guaranteed to develop 202 i.hp. at the most economical point of cutoff with a steam pressure at the throttle of 125 lb., a back pressure of 3 lb. and a steam consumption at full load of 22½ lb.; three-fourths load, 23½ lb., and one-half load, 26½ lb. One-half of one per cent. regulation is guaranteed at 20 lb. above or below the normal steam pressure and one per cent. regulation from no load to full load, the engine resuming its normal speed in three revolutions.

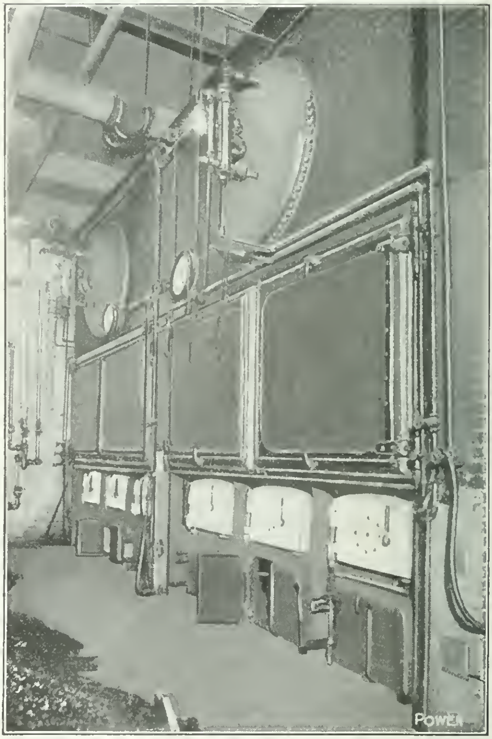


Fig. 2. The 270-Hp. Down-Flow Boilers

Direct-connected to each of these engines is a 240-volt, 60-cycle, two-phase, 30-pole, 150-kv.-a., 120-kw. at 80 per cent. power factor, engine-type, revolving-field, alternating-current generator, at 225 r.p.m. Each generator has an 8-pole, 10-kw., 125-volt, direct-connected exciter. The generators are guaranteed to have a regulation at 100 per cent. power factor of within 6 per cent. and at 80 per cent. power factor of within 20 per cent., the engine regulation being as above. The temperature rise with full load at 80 per cent. power factor is not to exceed 35 deg. C. Fig. 3 is a view of the engine room.

Piping

The high-pressure piping system is for 125 lb. working pressure and is insulated with 85 per cent. magnesia covering. A 10-in. steam header runs above the boilers to the engine room, from which connections are made to the several units. There is a 6-in. connection between each boiler and the header, a safety nonreturn angle valve being placed at the boiler and a gate valve at the connection to the header. In the engine room a separate connection, valved at the header, is made to each of the two high-speed engines and to the Corliss engine operating the ammonia compressor for the refrigerating system.

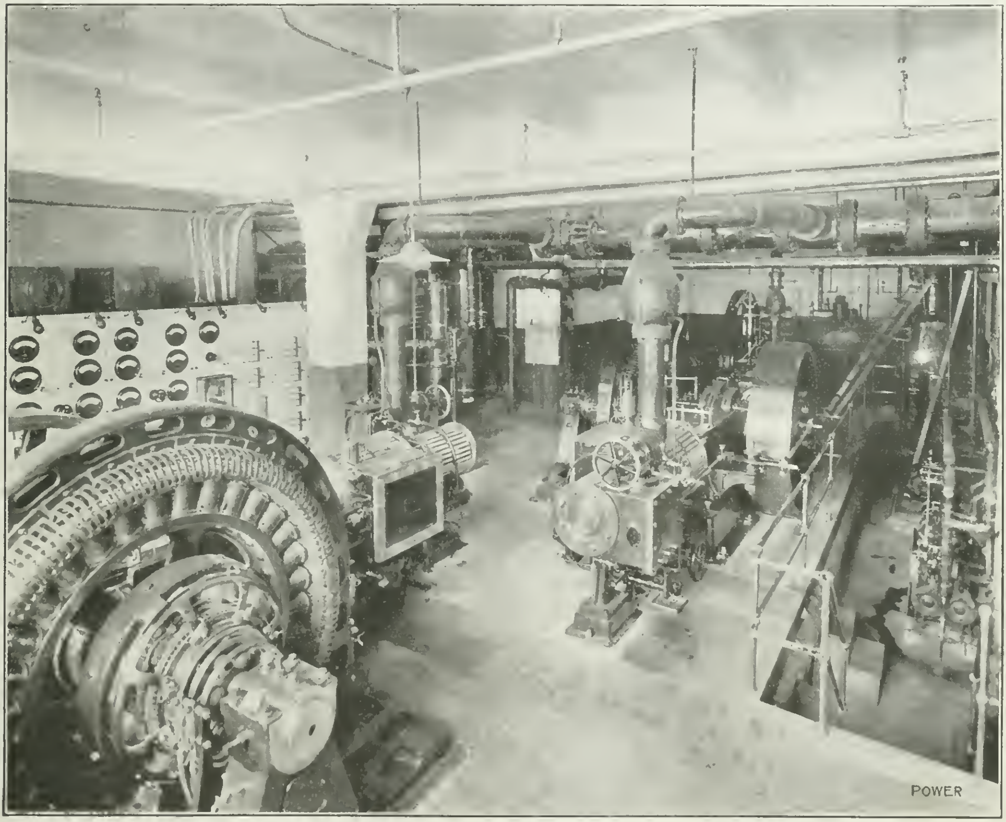


Fig. 3. View of the Engine Room of the Acme Tea Co.

Branches from the header supply the deep-well pump, the Underwriters fire pump and the steam pump used for brine-circulating purposes. A 5-in. branch is also taken from this header to supply the steam-operated boiler-feed pump and also through separate reducing valves the low-pressure steam line to the ovens and humidifier. This branch also supplies any low-pressure steam required to supplement the exhaust steam for the vacuum steam-heating system. A plan of the plant and piping is shown in Fig. 1.

Heating

Direct radiation is used for the heating system except in the mixing room; here the blower system is employed. All direct radiation is in the form of cast-iron wall radiators on the side walls and of pipe coils of manifold-header type with expansion bends on the ceiling of the cooling room and the driveway. On the return of each unit of radiation, also on the blower coils and at drip points, a thermostatic valve automatically relieves the radiators and piping of air and water of condensation and prevents the escape of steam. All returns are conveyed to a vacuum pump in the engine room and discharge through an air-separating tank to the feed-water heater. Because of the ovens, heating in the bake room would be superfluous when they are in operation, and therefore only a small amount of radiation is provided to prevent freezing when the ovens are not in service.

Switching Apparatus

For the electrical system the main switchboard of polished blue Vermont marble consists of two generator panels, a total-load panel and one light and one power feeder panel. Each generator panel has a separate voltmeter and ammeter for each of the two phases of the system and an ammeter and voltmeter for the exciter. Double-pole circuit-breakers are provided on each phase, together with a four-pole main switch, exciter and field switches and there are plug receptacles for testing for grounds and for synchronizing. The rheostats for the generators and exciters are of the concentric type. The total load panel has a power-factor indicator, voltage regulator, an equalizer rheostat for the two exciters, and two watt-hour meters, one for light and the other for power.

All of the switches on the power and lighting feeder panels are of the double-throw type and are connected to separate busbars in the rear of the board. Thus, either the break-down service or the current from the generators in the engine room can be supplied interchangeably to any feeder without interfering with the current supplied to any of the other feeders. This makes it possible for the outside current to supplement that from the generators in the engine room, or to use the outside current and that from the generators.

Cable connections from the switchboard to the generators and exciters are made through iron conduit buried in the floor and passing through the concrete foundations of the engines to the pit under the generators, where connections are made to the generator and exciter lugs.

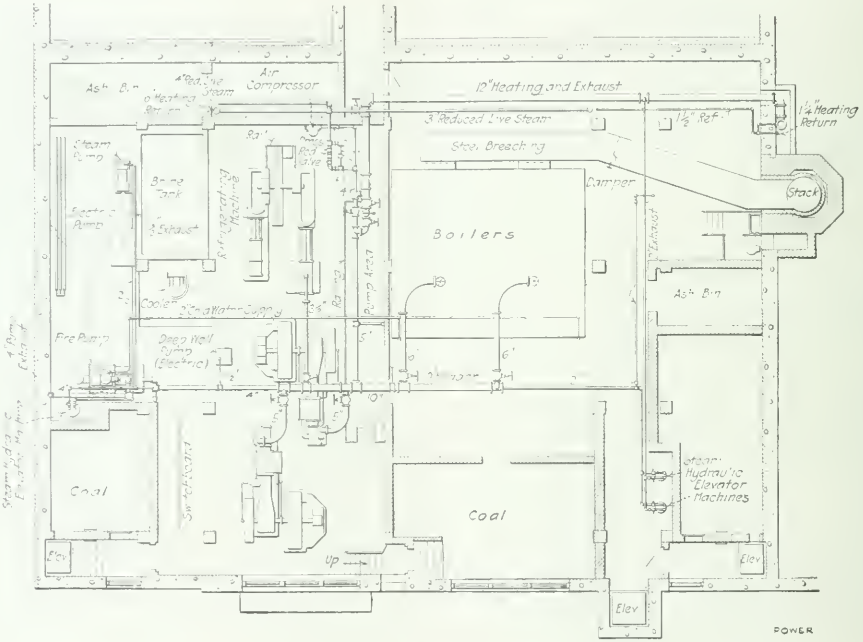


Fig 4. Plan of Power Plant Showing the Main Steam Piping

The lighting system consists of five four-wire, 220-volt feeders, extended to the centers of distribution throughout the building, where the four-wire lighting panel boards have a four-pole switch at each panel board to control all the lighting on it; two-pole switches are used to supply the branch circuits.

In any room requiring more than one lighting circuit they are balanced on the two phases of the system, and in case of large rooms having several ceiling circuits, proper balance is secured by placing every alternate circuit on the same phase, the remaining circuits being on the other phase. The lighting units consist of tungsten-filament lamps in as large units as practicable for the room to be lighted.

Water Supply

There are two sources of water-supply, one from the city main and the other from an artesian well in the engine room. An elevation of the pump piping is shown in Fig. 5.

The city supply has a pressure of from 10 to 44 lb. and is ordinarily sufficient to fill both the sprinkler and the house-supply tanks. A 3-in. line from the city main is brought to the pump area in the engine room, from which a 2-in. branch is extended to the house-supply and sprinkler tanks, both of which are filled at the top through a balanced tank valve automaticaly opening when the water level in the tank falls and closing against pressure when either tank is filled.

From the bottom of the house-supply tank an independent 1½-in. supply line is extended for filling the flushometer tank above the roof of the building. This water-supply is for the water-closets and urinals, thus separating it from the supply to the other parts of the building.

A second independent 1½-in. drop line is taken from the bottom of the tank and extended to two filters through which all water for drinking or bread-making purposes is obtained. From the filters a 1½-in. line is carried to the preparation room in the second story, at which point two branches are taken off, one supplying an automatic brine-coil water-cooler and the other an automatic hot-water heater. Another branch from the 3-in. water-supply in the engine room supplies the boiler-feed pumps, the makeup water for the feed-water heater, the double-pipe ammonia condenser coils of the refrigerating system, the humidifying system in the dough room, and the water jackets on the dough mixers.

The artesian well, which furnishes the other sources of supply, is 8 in. in diameter, is lined with wrought-iron pipe to solid rock and has a depth of 250 ft. This well is operated by a direct-connected, steam-driven, double-acting well pump having steam cylinder 10 in. in diameter, a well cylinder 5¾ in. and a 36-in. stroke. The water cylinder is approximately 150 ft. below the engine-room floor.

This pump has a combined check valve and air chamber and a 1½-in. pump governor attached to the steam supply and connected to the discharge. It is also provided with a relief valve discharging to the sewer through a connection open to the air. The pump is guaranteed to deliver 137 gal. of water per min. at 20 r.p.m. with a steam pressure of 70 lb. Upon test it developed a capacity of 165 gal. per min. at the speed mentioned and a capacity of 275 gal. per min. at 34 r.p.m.

The water from the well at a temperature of 56 deg. is delivered by the deep-well pump to a surge tank near the ceiling in the second story, from which tank the water goes by gravity to the humidifying system, condenser coils and feed-water heater in the order named. In the humidifier it will, in times of maximum demand in summer, be raised to not exceeding 70 deg., after which it will overflow from the humidifier and pass to the condenser coils. Even at 70 deg., this overflow water in passing through the humidifier will be cooler than the water in the city mains during the hot summer months, and will for that reason be more economical to use. Provision is also made for automatically passing direct to the condenser at its original temperature any well water not needed by the humidifier, without interference.

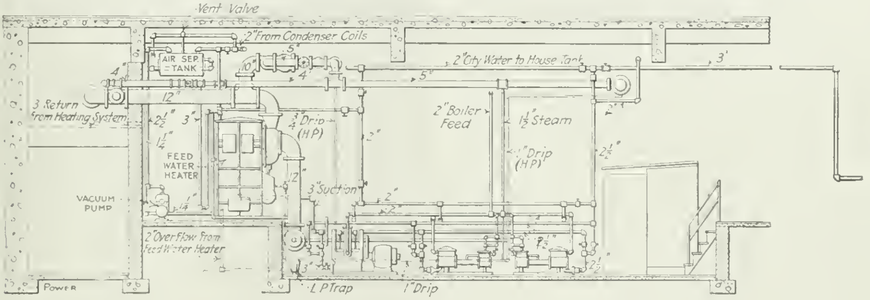


FIG. 5. PIPING OF PUMPS AND HEATER IN ELEVATION

PRINCIPAL EQUIPMENT OF THE POWER PLANT OF THE ACME TEA COMPANY

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers.	Parker down-flow	270 hp	Main units	One held in reserve	Parker Boiler Co
2	Grates.	McClave		Boiler furnaces	Hand shaking	McClave-Brooks Co
1	Chimney.	Radial brick	127′ 10″ x 54″ dia	Furnace draft	Natural draft	H. R. Heinicke
2	Engines.	Skinner	13½x20½x16 in	Main units	225 r.p.m., 125 lb. pressure	Skinner Engine Co
2	Generators.	Alternating current	150 kv a.	Main generators	225 r.p.m., 220 volt, 2 phase, 60 cycles	
2	Generators	Direct current	10 kw.	Exciter units	125 volt, 225 r.p.m.	
2	Valves..	Balanced		Tanks for house supply	Automatic	Thomas P. Ford Co
2	Filters.	Water		House water supply		Roberts Filter Mfg. Co
1	Pump..	Deep well.	10x5¾x36	Pumping from deep well	Steam driven	American Well Works Co
1	Governor.	Pump		On deep well pump		Watson & McDaniel Co
1	Compressor	Ammonia	35 ton	Refrigerating system	Steam driven	Vilter Mfg. Co

After passing through the condenser coils the water is raised from 70 deg. or under to 95 deg. or over, and is then discharged to be used as makeup water for the feed-water heater, and raised to about 210 deg. before going to the boiler. Any of this water not required for feed water then automatically overflows to the sewer by gravity.

The discharge line from the deep-well pump is connected to the main supplying the water from the city service, with valves so arranged that the city service or the deep-well water can be used interchangeably for the building, or by the manipulation of valves the deep-well pump can supply practically any group of apparatus in the building while the city service is supplying any other group. The system has been devised for the most economical use of water from either the city service or the deep-well pump. All cooling water is conserved for use where it will be of the most advantage, so that the heat units once imparted are conserved progressively until the water is converted into steam, thus reusing the water to prevent waste.

By the cross-connection of the water-supplies these economies can be obtained either with the well or city water. If the well-water supply is short, this water can be used where most needed for cooling purposes, namely, in the humidifier and condenser coils, supplemented by city water in any other parts of the system.

REFRIGERATING SYSTEM

For the refrigerating system a 35-ton ammonia compressor is directly connected to a Corliss engine with a three-section, double-pipe, closed-type condenser. Cooling throughout the plant is performed by the circulation of calcium brine to the cold-storage room in the basement, to the refrigerator in the second story, the water cooler in the preparation room, and to supplement the well-water supply to the humidifier in the mixing room in excessively hot weather. A brine cooler and one steam pump and one electrically driven brine-circulating pump are in the basement. There is a brine-storage tank to give a reserve capacity and render unnecessary the continuous operation of the refrigeration system and to afford opportunity for changes or repairs.

SPRINKLER SYSTEM

For fire-protection, a 30,000-gal. sprinkler tank 30 ft. above the roof supplies the automatic sprinklers on the wet-pipe system except in the wagon shed, where, owing to the possibility of freezing, the dry-pipe system is used. A 1000-gal. Underwriters steam fire pump piped to the city water mains supplements the gravity tank in supplying the sprinkler system. A feature of the piping in the bake room is that of running the sprinkler mains through the deep girders by means of pipe sleeves put in the forms before the concrete was poured, thus permitting both mains and branches to be placed near the ceiling and neither form an obstruction nor mar the finished appearance of the room.

A steam-driven air compressor maintains the pressure on the dry-pipe sprinklers and is also utilized in connection with an air-storage tank for supplying compressed air to outlets throughout the building for blowing flour dust from the motors and other machines.

Both the design of the building and the installation of the complete mechanical equipment were in charge of the architectural, structural and mechanical departments of Ballinger & Perrot, Philadelphia, Penn.

* *

Things of Interest in Recent Turbine Design

SYNOPSIS—Considers the most important of those changes in design and materials that have developed large turbines.

*

LARGE TURBINES IN LAND PRACTICE

At the Stuart St. station of the Manchester (Eng.) Corporation, a Zoelly impulse-type turbine driving a Siemens alternator of 15,000-kw. capacity has recently been installed. The New York Edison Co. has a 30,000-hp. Curtis unit at its Waterside Station, New York City. The Interborough Rapid Transit Co., of the same place, will have three Westinghouse turbines of 30,000 kw. each. Each unit is divided into two sets mechanically independent of each other, but as a heat engine the unit of two rotary elements must be regarded as one machine. The Kommunale Elektrizitatswerke at Hagen, Germany, has installed a Brown-Boveri turbo-alternator giving a maximum output of 25,000 kw. at 11,000 volts. The Philadelphia Electric Co. has put in two horizontal turbo-generators, one of 30,000 kw., 25 cycles, the other of 35,000 kw. and furnishing current at 60 cycles. These examples illustrate the enormous capacities which have now been obtained in steam-turbine land practice.

MARINE TURBINES OF LARGE CAPACITIES

At sea, large steam turbines are being introduced. In a paper which Sir Charles A. Parsons read in March, 1913, before the Institution of Naval Architects, summarized in *International Marine Engineering*, June, 1913, he pointed out that there were in service cargo steamers, channel steamers and warships about 26,000 hp. developed by steam turbine and transmitted through mechanical gearing. At the time when he gave this lecture, there were under construction turbine machinery and mechanical gearing representing a transmission of over 120,000 hp., including two installations of over 20,000 hp. each. In other large vessels the efficiency of the steam installation is due chiefly to combining exhaust-steam turbines with large-capacity reciprocating engines. Harland & Wolff, Ltd., have specialized on this combination of propelling machinery, and in the White Star liner "Britannic," for example, the steam drawn from the exhaust of the reciprocating engine passes at about 10-lb. pressure into an exhaust-steam turbine which develops 18,000 hp. The "Aquitania," built by John Brown & Co., Ltd., of Clydebank, is propelled by Parsons turbines, arranged on a triple-expansion system and driving four propellers, the total horsepower being 56,000. The introduction of the steam turbine has been made extensively in battleship design and T. G. Owens, of Vickers, Ltd., in a paper read recently at the Institution of Naval Architects, England, on "Questions Relating to Battleship Design," as reported in the engineering supplement of the London *Times*, stated that whereas the power obtained on predreadnaught vessels was 10.2 i.hp. per ton of machinery, the shaft horsepower obtained per ton in the earliest turbine-driven battleships was 12.25 to 13.75.

The increase of efficiency in large power units is a marked property of the steam turbine, and since, as compared with other forms of prime movers, the boiler and steam turbine unit does not, perhaps, stand highest in thermal efficiency, the increase in efficiency obtained by the increase in size of the unit is of importance.

One of the main reasons why the steam turbine has obtained such wide application as compared with other forms of units is that while as contrasted, say, with an internal-combustion engine, the thermal efficiency of the whole plant may be slightly lower, standing charges on the initial cost of the turbine plant are low and the cost of maintenance and supervision is low. Both of these factors are dependent on the simplicity of turbine design and construction.

PERFORMANCES OF SOME LARGE TURBINES

To show the performances obtained with large steam turbines, figures given by the *Electrical Review* of London for the Brown-Boveri turbine referred to may be mentioned. When working with steam at 350 deg. C (662 deg. F.) and 13.5 atmospheres (200 lb. pressure) and at 1000 r.p.m. this machine has a guaranteed steam consumption of 5.2 kg. (11.46 lb.) per kilowatt-hour at normal load; 5.43 kg. (11.97 lb.) at three-quarter load; 5.85 kg. (12.89 lb.) at half load. The 30,000-kw. Philadelphia turbine is supplied with steam at 215 lb. pressure at the throttle, superheat not exceeding 200 deg. F., and back pressure not exceeding 1½ in. of mercury. This is guaranteed for 12.45 lb. per kilowatt-hour at 15,000 kw., 11.9 lb. at 22,500 kw., and 12.15 lb. at 30,000 kw. The 35,000-kw. machine is guaranteed under the same conditions for 12.9 lb. of steam at 15,000 kw., 11.9 lb. at 25,000 kw., 12 lb. at 30,000 kw., and 12.6 lb. at 35,000 kw. Considering a smaller machine, the 15,000-kw. set at Manchester (see *Electrical Review*, London, July 3, 1911) with 190 lb. pressure steam at a total temperature of 530 deg. F., 27½-in. vacuum and power factor of 0.95, is guaranteed for 16.95 lb. of steam at quarter load, 14.92 lb. at half load, 14.12 lb. at three-quarter load, 13.65 lb. at full load, and 14.25 lb. at 25 per cent. overload.

FLOOR SPACE NEEDED BY LARGE TURBINES

One of the noteworthy features of modern turbine design is the economy of space. In the case of the turbo-generator sets installed for the Interborough Rapid Transit Co., the necessary space was obtained by clearing out four engine-driven sets of the slow-speed Corliss type which had a combined capacity of only 28,000 kw. Each of the old sets had two horizontal high-pressure cylinders, each 44 in. diameter, and two vertical low-pressure cylinders, each 88 in. diameter with a common stroke of 60 in. The total capacity to be put in the same space is 90,000 kw. for the turbines. The 25,000-kw. turbo-alternator at Hagen occupies a floor space of 16x4.2 meters (722.78 sq.ft.), this being the equivalent of a floor space of 0.029 sq.ft. per kilowatt of capacity.

Vertical turbines have been largely installed, but, as pointed out by R. F. Halliwell in a paper before the Manchester Association of Engineers (see *Vulcan*, September, 1913), although the vertical-shaft arrangement was satisfactory in running, it was found that for large units an excessive amount of head room was necessary. The horizontal arrangement presents advantages in accessibility and the more favorable position of the generator. In some places where space was costly, it has been found advantageous with reaction turbines to combine an impulse element to save length on the turbine, as pointed out by A. Q. Carnegie in the discusssion on a paper by W. C. Mountain, before the North of England Institute of Mining & Mechanical Engineers. Mr. Carnegie also pointed out (see *Iron & Coal Trades Review*, London, Aug. 7, 1914) that whereas Mr. Mountain had mentioned that the present makers of the Parsons turbine almost invariably fitted the Curtis or impulse wheel in the high-pressure stage of the mixed turbine, where economy was of the first importance, the pure reaction design must of necessity be adopted because the efficiency of reaction blading is considerably higher than that of the simple impulse or the velocity-compounded turbine.

The high speed of the turbine assists greatly in reducing the floor area required per unit of power delivered. Dr. C. P. Steinmetz, writing recently in the *General Electric Review* on the subject of energy density, points out that the highest velocities in rotating machinery are reached in the revolving rim of the steam-turbine disk, approaching 200 meters (356 ft.) per second and representing the stored energy of 5.6 watt-hours per kilogram (1 kilogram = 2.204 lb.) of rim weight. This has involved careful design to secure the use of suitable materials and proper construction to avoid damage under the severe conditions.

The exposure of the wheel to the action of superheated steam simultaneously with high stresses is a condition which requires careful choice of material. From a note in the *Iron & Coal Trades Review* recently, it appears that wrought iron has been found suitable for superheated-steam turbines. The tensile strength at 932 deg. F. fall from 52,600 lb. to 18,100 lb. But according to Rudeloff, at 400 deg. C. (752 deg. F.) it has a tensile strength of 15,000 lb. and an elongation of 40 per cent. and is used for blades in the Thyssen, the Melms and Pfenninger turbines. Although ordinary bronzes have not been satisfactory and pure nickel cannot be used on account of its fragility at high temperatures, special bronzes have given good results and tests at the laboratory of the Hungarian Royal Iron & Steel Works show that at high temperatures low-carbon steel is superior to high carbon. Guillet, on the basis of extensive tests, recommends for blades steel of 30 to 32 per cent. nickel and a maximum of 0.12 per cent. carbon. The coefficient of expansion of this steel is small and it does not rust in clean water.

The troubles which were formerly anticipated by the whipping of long shafts at high speeds have been overcome. In the discussion before the Mining Institute it was pointed out that at present shaft deflections and whirling speeds are calculated so as to avoid whirling and blade stripping. In low-speed Parsons reaction turbines the running speed is always lower than the first critical speed, while in high-speed turbines it is kept clear of the nearest of these speeds. That the shaft may run safely through the critical points the bearings are provided with concentric oil cushion tubes to damp out vibration. Mr. Carnegie referred to another point of mechanical construction which marks a distinct advance, that of end tightening the blades. Both the cylinder and spindle being arranged with shrouding strips, fine clearances are possible with safety owing to these clearances being adjustable in an axial direction, the shaft being free to move laterally without risk of making contact on the blading.

In the Ljungstrom turbine, to which reference will be made shortly, troubles from unequal expansion distortion are claimed to be less than with turbines of the cylindrical type. Even so, special features are introduced in the design to reduce such troubles to a minimum. For example, the blade rings are connected to the disks by thin conical rings of bulb-headed section to give a rigid drive and firm support to the ring and to allow for small changes of diameter.

Other mechanical properties which have received attention are the design of thrust bearings or alternative means of balancing end thrust. An interesting arrangement recently brought out by Sir C. A. Parsons (*Vulcan*, May, 1914), more particularly in connection with turbines for marine purposes, removes the danger of corrosion of the rotors, blades and other parts by interposing a strainer made of the same metals as the parts of the turbine subject to corrosion. If the steam carries corrosive agents they will attack this strainer and become chemically inactive before they reach the working parts of the turbine.

In marine practice the task of designing a propeller whose best performance would be given at the speeds required by a turbine driving it directly was a difficult problem, but a practical solution has been found in the introduction of speed-reducing devices of various types, while on land, particularly in connection with electrical installations, the direct coupling of dynamos and alternators to the turbine, although successfully accomplished, requires special means of clamping the rotor windings, the commutator, etc., to resist the high centrifugal force.

One form of turbine reduction gear, as made by the Westinghouse Machine Co., has a floating frame carrying a double helical pinion, which is able to adjust itself and allow the pinion to assume a deflection in accordance with any load which is being transmitted. This enables the tooth pressure to be equally distributed across the whole working face of the gear. Special oiling arrangements are provided and oil actuates floating frame pistons regulating the amount of movement which this floating frame takes. Incidentally, this arrangement makes it possible to quickly determine the shaft horse power transmitted. This type of gear was installed on the United States naval collier "Neptune." Geared turbines have also been fitted in connection with British vessels as described in the paper before the Institute of Naval Architects by Sir C. A. Parsons. The efficiency of this arrangement is, of course, determined by the efficiency of the modern helical gear, which is high.

An alternative system of speed reduction is that developed by Dr. Fottinger, in which the hydraulic pressure is created by a water turbine mounted on the steam-turbine shaft; this hydraulic pressure drives a second water turbine on the propeller shaft. The system has been applied extensively in marine practice. It is stated that the efficiency of the system can be brought up to 91 per cent. Another system of speed reduction is electrical. The United States Government collier "Jupiter" has a turbo-electric-generating unit of the three-phase type giving about 5000 kw., 2300 volts at 2000 r.p.m., while the two propeller shafts each have an induction motor running at 110 r.p.m., the ratio of speed reduction, 18 to 1 (disregarding slip of the motors), being accomplished with excellent efficiency, considering the double conversion from mechanical to electrical and back from electrical to mechanical power. Full particulars of this installation are contained in *International Marine Engineering* of August, 1913. In Great Britain considerable work has been done in the same general direction by S. A. Mavor. A point with regard to the interposition of electrical apparatus of this kind is that it gives a simple method of reversing the propeller.

On land the problem of speed reduction is perhaps not so pressing and yet cases arise where it is convenient to utilize a slower speed than that given directly by a turbine. For example, it is of undoubted advantage in direct-current electric plants to run at moderate speed rather than the high speeds required by some types of turbines. An interesting method by means of which the inherent high speed of the turbines is reduced in a simple and practical manner to the medium speed most convenient for some forms of electric machinery drive is given in the Ljungstrom turbine, which is manufactured in Great Britain by the British Electrical Co., Ltd., of Loughborough. This consists of a nest of rings placed concentrically to one another, each ring being composed of horizontal turbine blades. The alternate rings are connected to a fixture at opposite ends so that rings connected to one fixture intermesh with the rings connected to the other. Each system of blades is connected to a separate shaft. Steam is admitted at the center of the arrangement and passes outward radially; thus the sets of rings of blades react on one another. If the loads on the two shafts are equal, these shafts turn at an equal speed in opposite directions. To the end of each of these shafts is connected an electric generator and arrangements are made to connect these generators together electrically so that the load on each is kept the same. In this way the speed of the generator is reduced to half the speed of the blades with relation to one another. A description of the Ljungstrom turbine will be found in *Engineering*, London, for April 12 and 19, 1912.

The concentration of a large amount of power in one prime mover has brought with it the problems of supplying sufficient steam for each turbine set, resulting in changes in the design of boiler houses and a remarkable development of auxiliary apparatus.

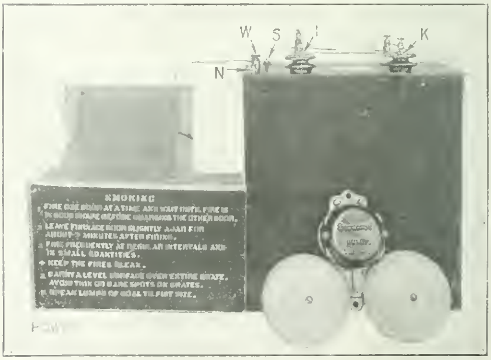
Smoke Recorder and Monitor

By W. W. Strong

The smoke recorder and monitor here described is planned to give an instantaneous record or warning that unburned hydrocarbon vapors are being emitted from the stack. With its aid the fireman may quickly make correct adjustments to the furnace. An illuminated set of directions for properly firing the given furnace and telling just how to prevent making smoke can be placed near the furnace door.

This type of recorder and monitor operates electrically, and is therefore almost instantaneous. The basic part of the apparatus is a small transformer using the energy of an ordinary electric lamp. The efficiency and dependability of the transformer are well known. Of course, these instruments must be essentially as efficient and dependable in their action as the transformer.

The action of the recorder and monitor depends upon the variable conductivity of the flue gases accordingly as more or less smoke is present in them. When the smoke is dense the conductivity is small, whereas the transparent flue gases from a furnace are comparatively good conductors. In the stack there is a gap in the high-tension circuit of the transformer and there are gaps in the circuit leading to a condenser; all are in parallel. When there is smoke the condenser is charged and this closes an electric circuit and operates a watch or recording clock. When there is no smoke the discharge occurs in the stack and nothing happens. By changing the length of the gaps the recorder may be made to record almost any density of smoke or fumes; for example, No. 2 of the Ringlemann scale.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SMOKING
1 FIRE ONE DOOR AT A TIME AND WAIT UNTIL FIRE IS IN GOOD SHAPE BEFORE CHANGING THE OTHER DOOR.
2 LEAVE FIREPLACE DOOR SLIGHTLY AJAR FOR ABOUT 2 MINUTES AFTER FIRING.
3 FIRE FREQUENTLY AT REGULAR INTERVALS AND IN SMALL QUANTITIES.
4 KEEP THE FIRES CLEAN.
5 CARRY A LEVEL SURFACE OVER ENTIRE GRATE. AVOID THIN OR BARE SPOTS ON GRATES.
6 BREAK LUMPS OF COAL TO FIST SIZE.

Fig. 1. Firing Directions on the Smoke Monitor-Recorder

The Smoke Monitor

Fig. 1 and the right portion of Fig. 2 show smoke monitors, the one in Fig. 2 being portable. This apparatus rings a bell and illuminates a sign when the stack is disobeying the city ordinance by emitting dense smoke. The directions are drawn for the particular stack so that by following them the fireman can obtain as nearly a smokeless stack as is possible with a maximum efficiency. In Fig. 1 these directions are for a hand-fired plant. The directions can be made to apply to a mechanical stoker just as well. In the above case these directions are:

1. Fire one door at a time and wait until the fire is in good shape before charging the other door.

2. Leave the furnace door slightly ajar for about two minutes after firing.

3. Fire frequently, at regular intervals and in small quantities.

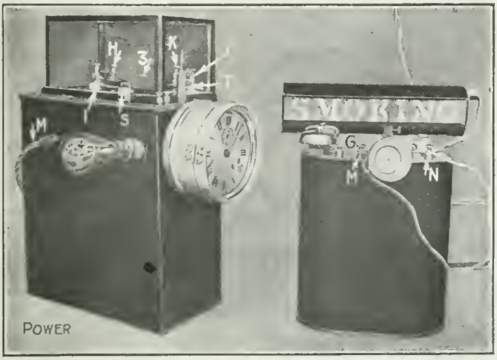

FIG. 2. ANOTHER TYPE OF MONITOR

4. Keep the fires clean.

5. Carry a level surface over the entire grate. Avoid thin or bare spots on grates.

6. Break lumps of coal to fist size.

In Fig. 2 is shown a smoke recorder on the left and a portable smoke recorder and monitor on the right. In one case an engine-room clock is used to add the total time that the stack smokes, the clock going only when the smoke exceeds a certain density, say, No. 2 on the Ringlemann scale. *I* and *K* are the high-tension terminals of the transformer; *M* and *N* are the low-tension terminals, to be connected to any alternating-current lamp socket; *S* is a rod holding a spring which adjusts the tension on one of the condenser plates. This is practically the only adjustment that it is necessary to make, the tension being decreased as the contact points gradually wear away. In the case of the recorder there are no contact points; in fact, there is nothing except the clock to wear out. A graphic recorder can be made to operate in the same way.

The smoke monitors and recorders are simple instruments containing practically no moving parts, using little electric current and no chemicals and act instantly and continuously. They can be easily covered with a case so that no one can come in contact with the high-tension parts without lifting the case, and this breaks the primary current at *S*.

*

Manufacturing Plant Wrecked by Shell Fire

The illustration shows the ruins of the Rochet-Schneider motor works at Albert, France, after bombardment. This complete demolition evidently was not caused by solid shot, but by shells designed to cause fire. In engineering parlance they seem to have been 100 per cent. efficient in destruction. The output of these works is probably the best known in this country of any of the foreign-made gasoline motors and motor vehicles. The copyrighted photograph was obtained by courtesy of Underwood & Underwood.

RUINS OF THE ROCHET-SCHNEIDER MOTOR WORKS AT ALBERT, FRANCE

Equipment and Methods in Largest Refrigeration System--IV

By Charles H. Bromley

SYNOPSIS—Why one of the large brine pumps runs at 80 r.p.m. without causing surging in the line. Metallic packing is used for the plungers of the large brine pumps. Interesting provisions for preventing corrosion of the brine-pump plunger. The specific gravity of the brine is changed for the winter and summer months.

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Other Practice at Sargent's Wharf

This, the fourth article of the series, treats of the miscellaneous practice at the Sargent's Wharf plant of the Quincy Market, Cold Storage & Warehouse Co., Boston, Mass. When a pump is forcing considerably over 10,000.000 gal. of brine per day directly into a system having an aggregate of over five miles of piping and 800 separate refrigerating services—and to do this, the pump must be run as high as from 65 to 80 r.p.m.—there must be no surging of the brine if the pump is to remain in good condition and leaks are to be prevented in the system. The pump, Fig. 16, is able to run at these and even higher speeds because at no time do streams running in different or opposing directions meet each other until the direction of each is the same.

All of the pot-type suction chambers communicate with one another, and their relative location is such that the bottom of the suction end practically forms a circular chamber. Should surging begin in the suction, the brine, when it surges into the pump, would tend to "chase itself" around the circular chamber under the valve and plungers. Wherever there is likelihood of shock due to sudden stoppage of flow or change in direction of flow—as, for example, where the suction comes to the pump at right angles from below the pump—large air chambers have been provided, their center lines being a continuation of a center line dropped through the vertical length of suction pipe.

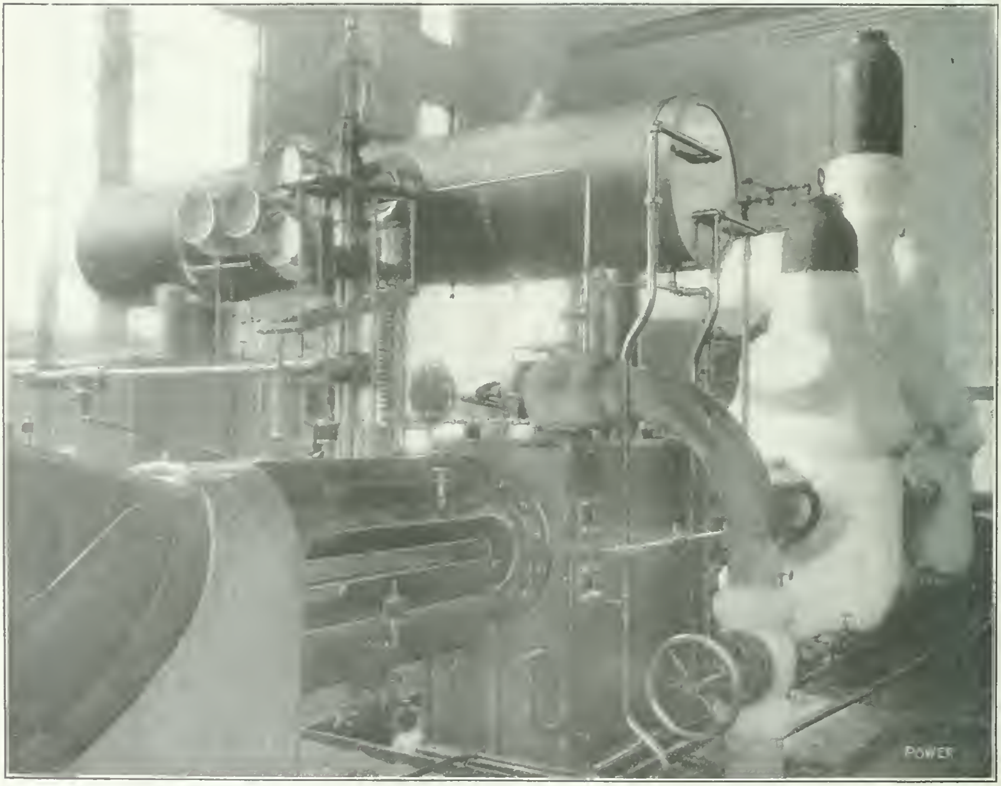

Fig. 16. This Is Believed to Be the Largest Brine Pump in Use

This pump is capable of handling 10,000,000 gal. of brine every 24 hr., and may be run quietly at the unusually high speed (for a pump so large) of 70 to 80 r.p.m.

As the brine leaves the discharge chambers on its way to the main discharge line, opposing streams from each side of the pump are deflected by a baffle placed in the special tee fittings which direct these two streams into the discharge pipe. In this fitting is a baffle which conforms in shape to that of the tee. The baffle forms two nozzles in the discharge line which so converge that the velocity of the water through the nozzle, or rather at the end of it, will counteract any surging that may tend to be created. Each air chamber is provided with a gage glass which shows the amount the brine surges. The pump was running at more than 65 r.p.m. when the writer saw it, and the columns of water in the glasses did not move more than 1/4 in. in any glass.

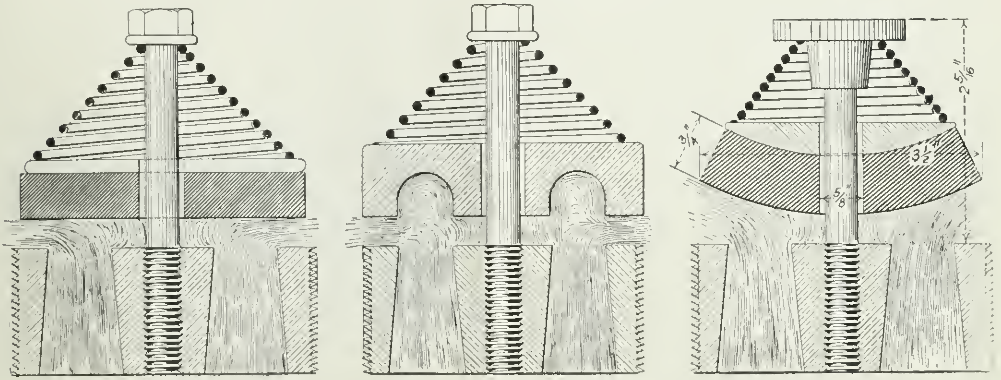

Fig. 17. Fig. 18. Fig. 19.

Flow of Water under Pump Valves of Different Designs

Fig. 17—Water Deflected at Right Angles to Flow. Fig. 18—Water Reacting Back on Itself. Fig. 19—Valve used at Sargent's Wharf; Soft Rubber Disk, Giving Gradual Change in Direction of Flow.

The Brine-Pump Valve

All pump valves except for the condenser and hot-water pumps are of standard design and size and are interchangeable. There are about a thousand of these, one of which is shown in Fig. 19. The disk or valve is of soft rubber and the saucer form of plate is adapted for use with it, so that the direction of flow of the water would have to be changed as little as possible. With a flat valve the water comes up under it and is directed at right angles as shown in Fig. 17, and with other types of valves, much water comes up under them and, due to the shape of the latter, is directed down against itself, just as in a Pelton bucket, thus offering considerable resistance to its flow. The action is shown in Fig. 18. Despite the fact that in America this type of pump valve is used but little and that some authorities on pumps claim that they have little advantage over other valves, experience with many kinds at the Sargent's Wharf plant shows that the pump will give an appreciably greater capacity with these than with other types.

Pump Plungers Corrode Rapidly

The pump plungers are of cast iron and are provided with metal packing, with just enough leakage allowed to obtain the necessary lubrication. This packing is of the company's own make and consists of 25 per cent. tin, 73 per cent. lead, and 2 per cent. antimony. It is made in rectangular form, and the rings are put in as shown in Fig. 20, which illustrates a section of a packed stuffing-box. As the gland is filled up, the projections begin forcing the other part of the ring against the 11-in. plunger.

It has been found that if the pump is stopped and the film of brine on the plunger dries off, corrosion begins almost immediately. The exposed part of the plunger can be wiped and cleaned, but that part under the gland retains the little pieces of rust which, after being wiped across the face of the packing, cut it enough to be objectionable.

To remedy this trouble, a split sleeve of cast iron will be made which will fit into the stuffing box and be in two parts with flanges midway between the two stuffing-boxes. Preparatory to putting on the sleeve, a ring or two of packing will be put into each stuffing-box; the flanges covering the plunger will be provided with bolts and nuts for pushing each half of the sleeve into its respective stuffing-box until the leakage of brine at either stuffing-box is as desired. The glands now used will be dispensed with. A water-tight cover is put over the flanges so that the entire plunger is inclosed. A plug

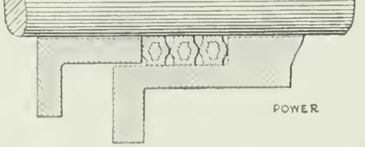

Fig. 20. Section of Stuffing-Box of Large Brine Pump, Showing Metallic Packing

ould be put into the sleeve to show the amount of leakage to readily determine if the sleeve sections should be screwed further apart and the packing tightened in the stuffing-box. The sleeve is, of course, cut away so that it does not touch the plunger. With the plungers provided, there will be no corrosion of the plungers when the pump is shut down, for the reason that they will be inclosed in brine, no air being able to get to them.

While either of the pumping engines used for street service may be operated on warehouse service, a two-stage, motor-driven centrifugal pump of 1000 gal. capacity is provided for the latter. The specific gravity of the brine for the warehouse system runs between 1.225 and 1.230 and that for the street system is kept at between 1.190 to 1.200. The make-up brine tank carries brine of 1.240 specific gravity and the brine for both the street and the warehouse system is "built up" by this brine. If too much is run into the street system, the operator opens the city water line into the brine circulating pump to bring down the specific gravity. It is the practice to drop the specific gravity of the brine to about 1.190 during the winter and spring, especially in the spring when the frost comes out of the ground, for it is at this time that bad breaks occur in the street piping, so that with the reduced specific gravity of the brine, the amount of calcium lost for a given amount of leakage is much less than it would be if the brine were of 1.200 or more specific gravity.

Formerly the main brine tank for the street system was on the discharge line and in the highest point in the system. This held the capacity down to that afforded by a pressure equal to the head from the tank; it also gave rise to troubles due to air becoming pocketed in the system, which, of course, further reduced the capacity. The air, it is believed, entered the system at a joint where the pressure in the pipe line from the pump was maximum and between this point and that at which the brine from the tank dropped to the minimum line pressure; some portion of the system was evidently under vacuum notwithstanding that there was a pressure of over 90 lb., indicated by the gage on the discharge line at the pump, and over 2 lb. on the suction line at the pump. This condition also gave rise to shocks in the line at the pump, because if the pump speed were increased, as on an urgent demand, the plungers would run away from the brine on the suction side. By putting the tank on the suction side, it increased the capacity of the street system without installing larger pipe, proportionate to whatever pressure the pipes would safely carry. Also, with the 40 lb. head pressure from the tank on the suction and with the discharge pressure increased to 102 lb., the entire system was under a pressure so much above atmospheric that the air troubles immediately ceased; also the troubles from shock were avoided because the pumps do not now run away from the brine.

Formerly, the usual practice of purchasing calcium in the 600-lb. tin-closed case was followed, but now this is not the case for it takes about ten days from the time the case arrives until it is unpacked and the calcium broken and dissolved, all of which means much labor. The calcium is now purchased in solution form and brought to the plant in 8000-gal. tank cars which are put on a siding; hose is attached to the tank and in thirty minutes the brine is in the make-up brine tank. This means a total saving of about $8 per ton over importing the solid calcium, as was done when the tariff on this chemical went off.

The fifth and last article of the series will treat of more of the interesting practice at Sargent's Wharf.

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Electrical Long-Distance Transmitting, Indicating and Recording System

A system for electrically transmitting long-distance readings of indicating and recording instruments has been placed on the market by the Bristol Co., Waterbury, Conn. Standard Bristol instruments are used having long-distance induction balance movements developed for this purpose by the Sangamo Electric Co. These instruments are intended to give automatic and continuous records of pressures, liquid levels, temperatures, mechanical motions, etc., up to 30 or 40 miles from the points at which the transmitters are located.

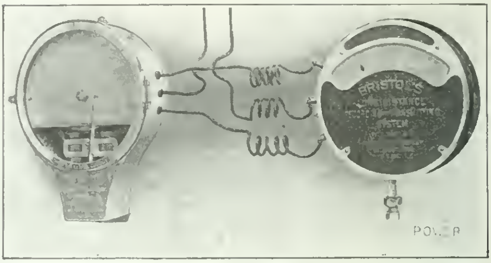


FIG. 1. BRISTOL TRANSMITTING INDICATOR AND RECEIVING RECORDER

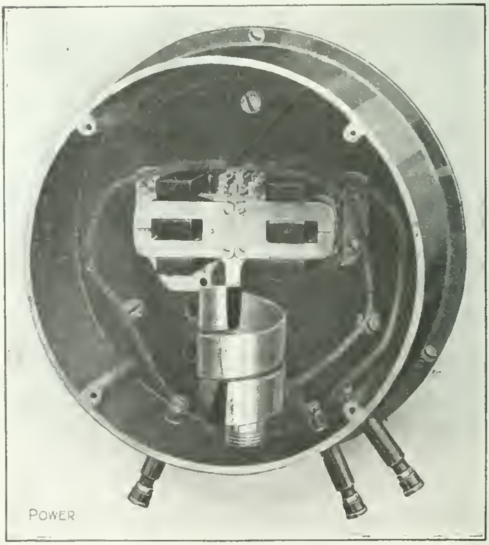


FIG. 2. INTERIOR VIEW OF THE TRANSMITTING INSTRUMENT

Fig. 1 shows a transmitting indicator for placing where the pressure or temperature, etc., is measured, and the receiving recorder which is at the remote point where the record is to be produced. The only restriction to the distance is the size of wire used and the voltage.

The two instruments are connected by three wires, one of which is connected to a source of alternating current, as, for instance, a lighting circuit. The transmitting device is mounted in a moistureproof case and can be put outdoors if necessary.

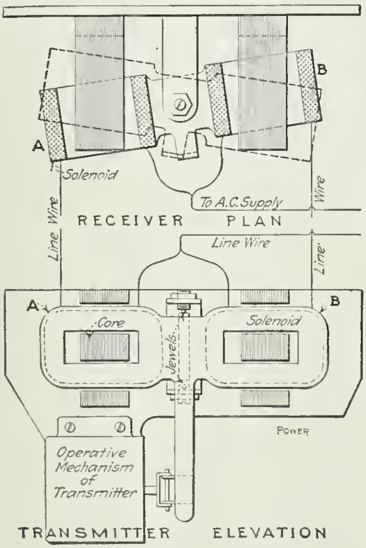


Fig. 3. Diagram of Transmitting and Receiving Apparatus

The fundamental principle of the system is that of the induction balance. The transmitting and receiving instruments are each equipped with two pairs of coils arranged to swing in a horizontal plane over iron cores. Fig. 2 shows the interior of one of the transmitting instruments. The helical pressure tube and the electrical transmitting device are shown in the operating position.

Fig. 3 is a detailed front and top outline diagram of the transmitting device, which is similar to the receiving device. The outfit consists of two pairs of mechanically balanced solenoids arranged to swing horizontally back and forth over the ends of soft-iron cores and connected in parallel to an alternating-current circuit. One pair of the solenoids is used for the transmitting instrument, the other for the receiving instrument. The bottom view of the transmitter shows one pair of the solenoids *A* and *B* on spools connected and supported on a shaft, the ends of which rest in jewel bearings and are free to swing back and forth over laminated soft-iron cores. The top view shows the solenoids *A* and *B* of the transmitter in section; the dotted outlines indicate the position to which the solenoids may swing.

A similar pair of balanced solenoids is placed in the receiving recorder or indicator at the distant point. When the solenoids *A* and *B* of the transmitter and receiver are connected in parallel to an alternating-current circuit and the transmitter coils *A* and *B* are held in a certain position by the operating mechanism located correspondingly to the water-level gage, pressure gage, thermometer, etc., the relative amounts of current flowing in the solenoids *A* and *B* will depend on their positions on the iron cores, due to the inductive effect.

At the receiving instrument the other pair of solenoids is mechanically balanced and free to take an angular position, which will be the same as that of the transmitter since the flow of current will be the same in the corresponding solenoids of the receiver as in the transmitter. If the angular position of the pair of solenoids at the transmitter is changed by the operating mechanism, thus moving one of the solenoids off and the other on to the iron cores, increasing the inductance in one solenoid and diminishing it in the other, the flow of current will be proportionately increased in one coil and diminished in the other. The variations of current at the distant receiver will correspond with the variations at the transmitter and cause the pair of solenoids of the receiver to seek a position of balance which will be the same as that of the solenoids of the transmitter.

In the transmitter the operating mechanism is linked to the balanced solenoids by an arm between the solenoids *A* and *B*. In the receiver the recording pen or the indicating pointer is connected to a similar arm through a multiplying mechanism.

Various combinations of transmitting and receiving instruments of either indicating or continuous recording type may be used, also a transmitter and receiver of either the indicating or recording type, or a combination outfit, including two transmitters and one receiving indicator connected to a two-point rotary switch so that readings may be obtained with the indicator of the pressures, temperatures, etc., from either of the transmitters if desirable.

⁂

A Characteristic of a Shunt Motor—There is one peculiarity of a shunt-wound motor as commonly used which is not always recognized. When the motor is operating "cold" (before the load has been on long enough for the motor to warm up) the speed is from 4 to 5 per cent lower than after the motor is warm. This is due to the lower resistance of the fields when cold.

⁂

The Area of a Safety Valve is determined by the grate area and the pressure to be carried on the boiler. A good formula for safety valve size is:

$$A = \frac{37.5 \times G}{P}$$

where A = Area of valve in sq.in.;
G = Area of grate in sq.ft.;
P = Absolute pressure in lb. per sq.in., or gage pressure plus 15 lb.

⁂

Heating of Bearings on electric generators and motors may be due to:

Excessive belt tension in which the pulley bearing will probably be hotter than the other. To overcome this, reduce the load or belt tension.

Failure of oil rings to revolve with the shaft; oil too low; poor grade of oil; grit in the bearing or a bent shaft. The remedy is obvious.

End thrust due to improper leveling or no lateral motion of the shaft—if a belt-driven machine, move the shaft back and forth with a stick pressed against the end of the shaft. The shaft should have a lateral movement of about ⅛ in. and should float when running. If it does not, it is probably held in one position by the belt, the pulley or the collar. Sometimes the armature projects out more on one side of the field coils than on the other; in this case, the magnetic pull of the field coils will draw the armature in and the pulley or collar may bind the bearing and cause heating.

Unequal air gap—See that the air gap is equal all around the armature, for, if it is nearer one pole-piece than another, the magnetic pull will be unequal

Performance of a Cinder Catcher

By M. Van Valkenburgh and M. H. Isenberg

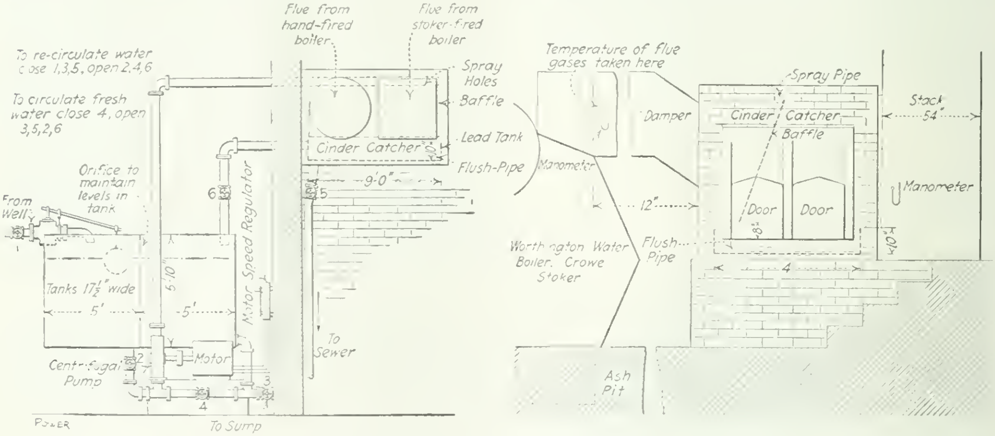
SYNOPSIS—Describes the performance of a wet-type cinder catcher in the plant of the Hotel St. George, Brooklyn, N. Y.

⁂

The tests here described were made at the Hotel St. George, Brooklyn, N. Y., by the writers under the direction of Prof. W. D. Ennis of the Polytechnic Institute of Brooklyn, to determine the percentage ratio of cinders caught to coal burned during an average day's run of twelve hours; to determine the calorific power of the cinders and the percentage ratio of heat lost through cinders to the initial heat in the fuel; and to determine the character of the water solution after circulating through the catcher for twelve hours.

The cinder catcher is in the flue leading from a Worthington water-tube boiler rated at 295 hp. and fitted with a Crowe chain-grate stoker. There is another unit which ordinarily discharges into this catcher, but at the time of this test it was being overhauled for repairs. The boiler has a grate surface of 82 sq.ft. and a heating surface of 2870 sq.ft., made up of 296 tubes 10 ft. long and 3 in. diameter. At the date of the test it was working under an overload, developing about 350 hp. The catcher, as will be seen from the illustration, is chiefly a sheet-steel baffle-plate with a film of water flowing over it. This plate is placed across the path of the flue gases so as to cause them to strike it and be deflected downward and through the narrow opening between it and the surface of the water in a receiving tank at the bottom. The baffle is 5x9 ft.; the receiving tank is 4x9 ft. and 10 in. deep, and the distance between the bottom of the baffle and the water is kept at about 8 in. As the gases come in contact with the water on the baffle they lose some of their cinders, but by far the greater amount is deposited with greatly increased velocity as they rush through the restricted opening at the bottom and strike the water in the tank.

The water for the catcher is pumped from a well into a tank, from which it flows by gravity through a ball-float valve into one of the two twin tanks shown. It may be pumped either continuously fresh or recirculated. In either case, a motor-driven centrifugal pump of about seventy-five gallons per minute capacity forces it from the tank to the top of the baffle in the cinder-catcher, whence it flows by gravity over the plate into the tank and, if recirculating, into the second twin tank or otherwise direct into the sewer. The tank as originally installed was of sheet steel, and the baffle was constructed of a series of sheet-steel plates riveted together. After two weeks' service, the tank had disintegrated so badly, due to the acid formed by the flue gases coming in contact with the water, that it had to be replaced by a lead tank. The baffle was also attacked at the rivets, necessitating the installation of a one-piece plate.


Flue from hand-fired boiler
Flue from stoker-fired boiler
To re-circulate water close 1,3,5, open 2,4,6
To circulate fresh water close 4, open 3,5,2,6
Spray Holes
Baffle
Lead Tank
Cinder Catcher
Flush-Pipe
9'0"
Orifice to maintain levels in tank
From Well
1
6
5
Motor Speed Regulator
5'10"
Tanks 17½" wide
5'
5'
To Sewer
Motor
Centrifugal Pump
2
3
4
To Sump
Power
Temperature of flue gases taken here
Spray Pipe
Damper
Cinder Catcher
Baffle
Stack
54"
Manometer
Manometer
12"
Door
Door
8"
10"
Worthington Water Boiler. Crowe Stoker
Flush Pipe
4
Ash Pit

General Elevation of Cinder-Catching Apparatus and Boiler

The cinder and the circulating tanks were flushed out clean prior to the start and the system adjusted for recirculating the water. Owing to an oversight, the flush valve was left partially open, allowing a constant small increase of fresh water into the system. However, as there were no accurate means at hand of determining the amount of water used, the relative error introduced was small.

There being no scale large enough to handle the conveyor used in hauling the coal to the furnace, it was found impossible to weigh every pound of coal put into the hoppers. During the twelve hours of the test, five conveyors of coal were weighed and their average taken. A record was kept of the number of loads used. The coal on the floor at the start was weighed and added to the total, and that at the finish was weighed and subtracted, the level in the stoker hoppers at the beginning and end of the test being kept the same. An average sample of the coal was sealed in a fruit jar for analysis.

Separate samples of the circulating water were taken at the return tank every hour during the run, and to obtain an average sample, half-pints were taken every fifteen minutes and poured into a large vessel. The temperature of the intake and the return water was noted every hour, as were the draft and the flue temperature.

Due to the rapid evaporation at the catcher, it was necessary from time to time to replenish the circulating water with fresh water from the well. The amount of evaporation was noted each time by measuring the fall of the level in the return tank. Some of this water was lost because the lead tank in the catcher had melted over on one edge, so that when the water level rose to this point, the water flowed away into the ground. It is probable that some of the cinders were carried away at this place.

After twelve hours' continuous service the circulating pump was stopped, the fires banked, and the contents of the tanks allowed to settle. When the water had become reasonably clear, it was gradually drawn off, leaving a layer of cinder in each of the three tanks. It was found impracticable to weigh the cinder directly. Accordingly, the depth of cinder in each tank was measured in several places, the layers being of uniform thickness, and the average depth in each tank found. A fruit jar was then packed loosely full of an average sample of the cinder and sealed. Having the dimensions of the catcher and the tanks, the total volume of cinders was readily calculated, and by measuring the volume in the jar and weighing its contents, the weight was obtained. Air-drying the jar of cinders and then weighing it gave the weight of dry cinders, from which the total weight of dry cinders and the percentage ratio of cinder to coal burned were calculated. A sample of dry cinder was saved for analysis.

The coal and cinders were analyzed for moisture, volatile combustible matter and ash, and their heat value determined by the Parr calorimeter. From these and the previous results, the percentage ratio of heat lost in cinders to initial heat in coal used was calculated.

The water samples were submitted to the methyl-orange test for acid and no trace of acid found. The alkali test, however, disclosed alkali markedly present, whence it was decided that a secondary reaction had occurred between the acid formed by the combination of the SO_2 and the SO_3 in the flue-gas and the water of the catcher and the cinder in the catcher tank.

To sum up: In the twelve-hour run, 2.2 per cent. of the coal burned was caught by the cinder catcher in the form of cinder. Calorific determinations showed a heating value for the coal of 14,000 B.t.u. per lb., and for the cinder of 3100 B.t.u. per lb. The percentage of heat lost in the cinder was therefore 0.486 per cent. The system required approximately 190 gal. of water per hour. The ratio of pounds of coal burned to gallons of water used is 5.33 to 1. The reduction in draft owing to the cinder catcher was 0.309 in. water.

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New Ventilating Fan and Blower

Many engine and boiler rooms where the air is contaminated with steam, dust, fumes, foul odors, etc., are benefited by putting in an artificial ventilating system. To relieve such conditions a new type of ventilating fan (Fig. 1) has been recently put on the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn. The fan differs from the older style in having more blades which are mounted on a wide central disk and which have the ends abruptly turned up. The air is thrown forward at high velocity instead of being widely spread out, and air cannot flow back through the center of the fan.

The unit is compact, and when in place the motor projects but little into the room. The motor is inclosed and protected from dust, dirt, moisture, etc. It has a high overload capacity and readily drives the fan even against a strong back pressure. Power is obtained from an electric-light circuit.

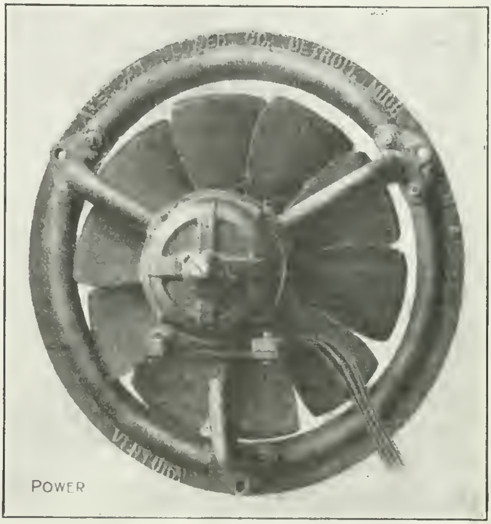

Fig. 1. New Design of Ventilating Fan

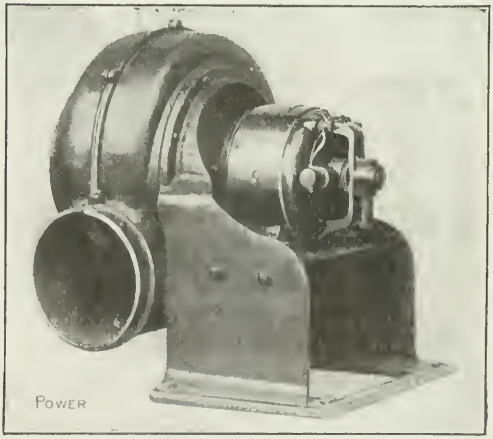

Fig. 2. Motor-Driven Blower

For forcing air through pipes, a Sirocco blower (Fig. 2) is supplied. It is suitable for forcing air out of underground and inside rooms, cooling motors, and for blowing away chips, shavings, etc.

Reconstructing Existing Plants*

By Osborn Monnett†

SYNOPSIS—Problems encountered in making fire-tube boilers smokeless under conditions of low headroom, lack of space in front of the boiler, or restrictions preventing excavation.

Other discussions of boiler settings have dealt with new installations where floor space and headroom were available for proper furnace designs. If no more were necessary to smoke suppression, the cities burning bituminous coal would not be cleaned up until all of the existing settings had been burned out and replaced by new work. To obviate such a long delay it is of utmost importance that the present plants be overhauled and put in condition to operate without smoke.

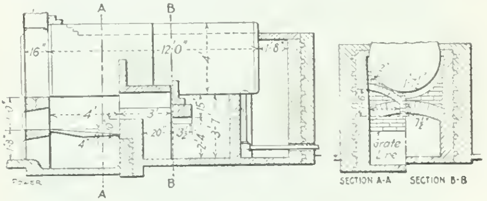

Fig. 1. Double-Arch Bridge-Wall Setting for Small Boiler; 22 In. from Dead Plate to Shell

When reconstructing plants the draft must be looked to first. Patch up the setting, clean out the doors and flue caps. Stop all leaks in the breeching, take out unnecessary turns and drops, and arrange to raise the stack if the load requires it. The breeching will probably be found too small, and when rebuilding, proper areas should be given as outlined in a previous article.

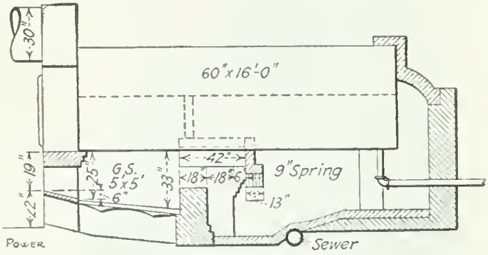

Fig. 2. Dead Plate to Shell 19 In., Lowered Dead Plate and Excavated Combustion Chamber

There are thousands of horizontal return-tubular boilers in use, installed years ago when low settings were the rule, which must be overhauled before any showing can be made in smoke reduction. In some fortunate cases these boilers may be raised or perhaps the foundations are in such shape that excavation may give proper headroom for the furnace installation. In other cases, the limitations of building construction make it impossible to raise the boiler, and because of floating foundations or building columns, excavation is out of the question.

Under these circumstances, it becomes a puzzle to know what to do with the setting to stop smoke. Fig. 1 is presented to show what can be done with a small boiler set low. A double-arch bridge-wall setting is applied to a 48-in.x12-ft. boiler set 22 in. above the dead plate. Proper areas have been so worked out that good results can be expected from the setting up to the capacity of the boiler.

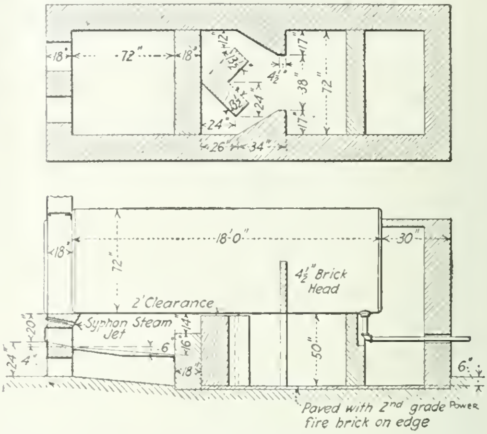

Fig. 3. No. 8 Furnace under 72-In. x 18-Ft. Boiler: 20 In. from Dead Plate to Shell

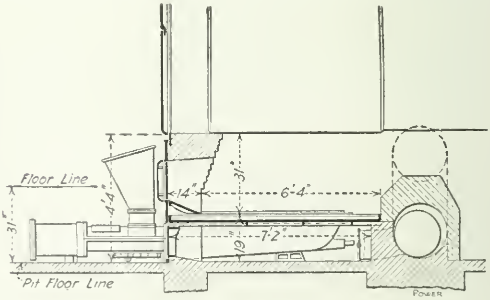

Fig. 4. Underfeed Stoker and Return-Tubular Boiler; 31 In. from Dead Plate to Shell

Larger boilers set 18 and 20 in. from the shell to the dead plate are much more difficult to clean up, and they are many. Fig. 2 shows a 60-in.x16-ft. boiler set extremely low. The distance from the shell to the dead plate is only 19 in. To get more volume over the grates the dead plate was pitched to give a drop of 6 in. at the inner edge, as shown in the drawing. This made possible a clearance of 33 in. between the grates and the shell at the bridge-wall, giving proper areas through the furnace and a fairly good vertical bridge-wall. Another peculiarity of the setting was that a sewer passed through

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†Smoke inspector, city of Chicago.

the combustion chamber and in excavating only enough material could be taken out to give the required areas under the arches. From here the floor of the combustion chamber was sloped up to its original height under the blowoff. This remodeled setting is operating successfully and shows what may be accomplished by an ingenious adaptation of design in special cases. It would not be recommended for a new installation, but it can be used where other arrangements are impossible.

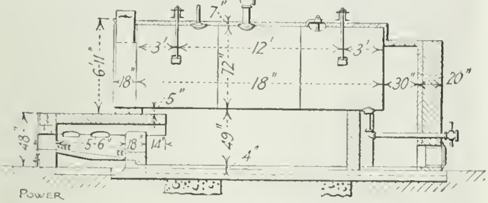

FIG. 5. BURKE GRAVITY-FEED FURNACE AND 72-IN. x 18-FT. RETURN-TUBULAR BOILER: 49 IN. FROM FLOOR TO SHELL

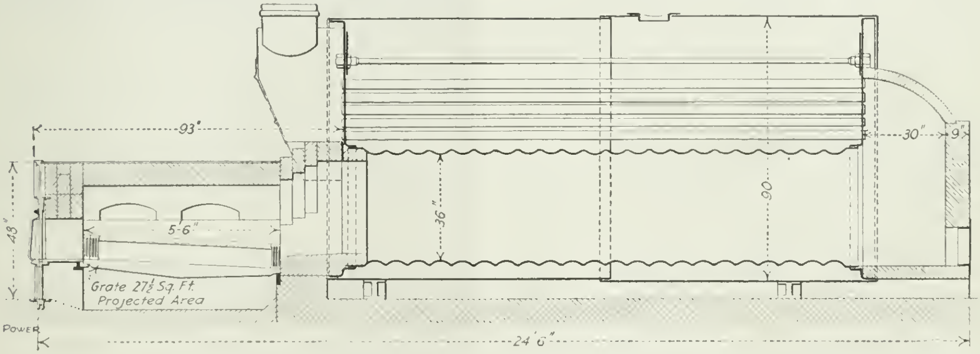

FIG. 6. CONTINENTAL BOILER, 150 HP., AND BURKE GRAVITY-FEED FURNACE

The No. 8 furnace shown on p. 166 of the Aug. 4 issue is generally much better adapted to low settings than any of the other furnaces. It is possible to work in such a setting on a 72 in.x18-ft. boiler with only 20 in. between the dead plate and the shell, though it will probably be found necessary to lower the combustion-chamber floor to get the proper areas through the setting. Fig. 3 is a typical installation with the areas worked out properly from the percentages of grate surface given in a previous article.

In connection with these old horizontal return-tubular settings, the possibilities of the underfeed stoker should be carefully considered. Fig. 4 shows a freak underfeed setting in which the dead plate is only 31 in. from the shell. This is about the lowest headroom permissible for the underfeed stoker, but the installation is running satisfactorily not only from the smoke standpoint but from maintenance. The total height of the setting from the floor line to the shell is 52 in.

Another possibility in connection with low settings for horizontal return-tubular boilers is the gravity-feed furnace. In places where the floor space is available, a Burke or McMillan furnace may be used with a tubular boiler, with a headroom of 48 in. between the floor and the shell. As shown in Fig. 5, the application is simple, and where the draft requirements are investigated at the same time and proper attention is given to operation, these furnaces will clean up an old horizontal return-tubular setting.

If floor space in front of the boiler is not available for an extension furnace, the problem may be solved by installing a Moore stoker. As has been shown previously, this stoker under tubular boilers up to 72 in.x18 ft. and 150-hp. capacity, requires only 18 in. of headroom. As shown on p. 712 of the Nov. 17 issue, the setting is made flush front and will be found of great advantage for installations requiring low headroom, especially where floor space is limited in front of the boiler.

Another condition frequently arises in connection with horizontal return-tubular boilers. Excavation is sometimes made to lower the furnace and firing floor and a pan is placed at the bottom while the floor of the combustion chamber is left at the original level of the ground. As a consequence, it is practically impossible to excavate in the combustion chamber for a deflection arch or anything approaching a double-arch bridge-wall setting.

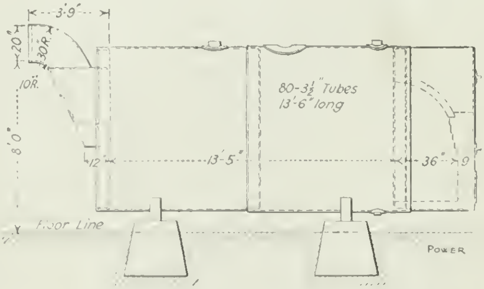

FIG. 7. CONTINENTAL BOILER WITH BREECHING INSTALLED IN HEADROOM TAKEN BY BOILER FITTINGS

Sometimes the settings are below the sewer level, so that the pan is made of metal to be water-tight; an attempt to disturb the setting will cause the firing floor to be flooded with water. This is an especially difficult installation to clean up with a hand-fired furnace.

If a No. 8 furnace cannot be worked in with the proper areas, a gravity-feed furnace may be used, provided the pan will allow full extension. If not, then only the underfeed stoker will fit the conditions, as it is the one type of furnace which can be installed in the pan without slightly excavating the ashpit.

For low headroom the Scotch marine or Continental type of boiler is another possibility. This boiler, with a plain setting, cannot be expected to operate within any reasonable smoke ordinance, so that some type of furnace must be applied to make it satisfactory. Fig. 6 shows the standard uptake for this type; it can be employed where reasonable headroom is available. Limited headroom, however, sometimes precludes the use of an uptake extending above the top of the boiler fittings. In this case a breeching connection (Fig. 7) can be used.

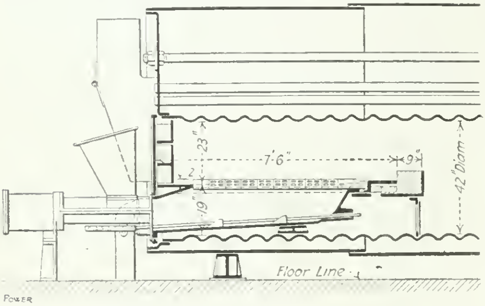

Fig. 8. Continental Boiler, 150 Hp., and Jones Underfeed Stoker

One point to be considered on this boiler is the depth of the combustion chamber. This should not be less than 30 in. in boilers up to 100-hp. capacity, and 36 in. to 150-hp. capacity.

An excellent combination is the Continental boiler and Jones stoker shown in Fig. 8. This stoker can be applied to a corrugated flue as small as 36 in. in diameter and where headroom is low it offers a satisfactory solution of the smoke problem.

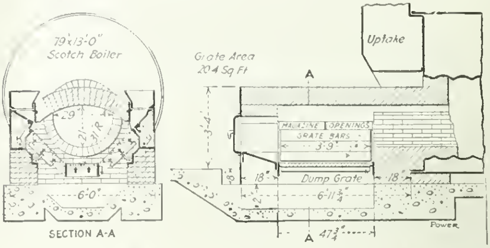

Fig. 9. Continental Boiler, 100 Hp., and McKenzie Furnace

The gravity-feed furnace can be easily installed under a Continental boiler and makes a good semi-stoker installation where draft is available and good operating conditions prevail. It is installed in front of the boiler and needs no extended description. Fig. 6 shows a typical Burke installation on one of these units.

Fig. 9 shows a characteristic McKenzie gravity-feed furnace serving a Continental boiler and also how simple the installation becomes if there is room in front of the boiler. The gravity-feed furnaces are especially appropriate for low-pressure plants using this type of boiler, because of the absence of steam to work a stoker engine.

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Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Hunter discusses the question of power production for mine operation with steam and with electrical generating units. He points out that operators of large mines find it economical to build a central station to supply electrical energy for several mines. He suggests that several small operators could advantageously run a central power plant for the benefit of all, each user paying his proportionate share of the expense.

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"Hunter," said I, the next day after visiting the Penn Mary power plant, "is it better for a mine operator to build his own power plant or to use central-station current for operating the mine? We have visited the mines employing both sources of electrical energy and it looks to me as if the coal operator could supply his own 'juice' cheaper than he can buy it, if he has a plant that is halfway fit. Some of them are not, I'll admit."

"Well," said Hunter, as we stepped out of the hotel at Johnstown, Penn., where we had rumpled the bed clothes during the night, "most coal-mine operators are up in the air when it comes to knowing just what saving power from either source will make. If no record has been kept of the cost of power production, the operator doesn't know if it is costing him more than what he can buy it for. He certainly has everything in his favor for doing so, because the fuel cost is low, the apparatus is simple, and the building to house it does not cost much."

"Say, some of the buildings are in a rather 'went' condition, aren't they, although several of the hoisting plants are kept up to the notch? It's the boiler houses that seem to reflect on the management more than the engine departments. However that may be, the two main things necessary to operate a power plant are coal and water, and both are had at the mine without the cost of bringing them from a distance."

"That's right, jump before you look," laughed Hunter, as we climbed onto a trolley car, bound for a mine a few miles distant. "The coal is right at the door, but its value should be figured at the price it would bring per ton if sold in the market. There is plenty of water for boiler and condenser use if—and it's a big IF—the water were good enough to use. In most instances it is not, because of acids, and then it is a case of obtaining good water from some other source. Water containing sulphuric acid will eat up boilers almost as fast as you can put them in place, which is discouraging.

"The boilers and engine units in a mine are usually of the most simple design, because the original operators did not have the foresight to put in the most efficient machinery. So, with cheap units, cheap men were hired to operate them, although better men are now being employed; a lot of them are mighty bright fellows."

"Aren't you a little hard on the mine operators?" I asked after handing the conductor a couple of nickels. "Isn't it true that, when most of the shafts were sunk, the only accepted form of power about a mine was steam? Besides, many of the mines were in operation long before the electric motor was known. Central-station power would mean an expensive changing of everything to electric drive, especially in the matter of mine pumping, wouldn't it?"

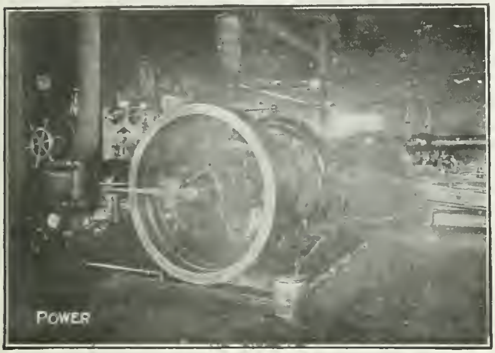

Fig. 1. A Dark, Gloomy Engine Room

"It certainly would," answered Hunter, "and the reason why some mine operators hesitate about putting in electric units is that, even with a certain rate quoted for central-station power, they are not sure what the total cost for power willl be, or whether there will be a saving or a loss.

"At some mines a twenty-four-hour service is wanted of the generating units; at others in the neighborhood, sixteen or twenty hours, as the motor-driven pumps would have to be operated during such periods to keep the mine free of water. In many mines the coal-cutting is done at night, which increases the load factor. Of course, the hoisting is confined to the day load, the few trips at night being for miscellaneous purposes. All fans will operate twenty-four hours, so that the greatest load will be during the day shift, which includes the breaker engines.

"Now, the mine operator figures that he has his steam equipment, and that if it is to be supplanted by electric drive the old apparatus must be scrapped or sold for little or nothing. Most of them cannot see that it will put any money in their pockets to displace machinery now performing their work for new apparatus that is going to cost several thousands of dollars. The plant may be dark, dirty and congested, but the wheels go 'round and that is what counts with them." (See Fig. 1.)

"Well, it is easy enough to see things from their standpoint, but I cannot see that it is always economy to balk at spending money for new machinery that will make a substantial saving in the cost of power production. I've been told—and I think it's true, judging from the scrap pile—that the foremost steel companies do not hesitate to substitute practically new machinery with something that will do the work better and cheaper, and that they find it to their advantage to do so. What works well in one place should be of value in the other. I have an idea that there are not enough data on hand on which Mr. Operator can base his figures to give an intelligent statement of what his steam plant is doing. How would you go about figuring the cost if, for instance, you were operating a mine?"

"One of the items that make up the cost of mining a ton of coal, dealing with the power end, is that of labor for operating the various engines, pumps, fans, hoists, etc. Then there is the depreciation, interest on the investment of power-plant equipment, fuel, repairs and general plant-operating expenses. Dividing the total tonnage of coal mined per day and loaded onto cars for shipment by the total cost of operating the power plant will give the cost per ton of coal produced for the market.

"This operating cost, excepting the labor and fuel, goes on whether the mine is working or not, although at a reduced rate, because fewer men are employed and not so much coal is burned in the boiler furnaces. The horsepower developed by the various engines about a mine can be determined by indicating them and striking an average horsepower output for working and nonworking days.

"The power of the fan engines, if it is not convenient to indicate them, can be calculated approximately from the size and speed of the engine, the steam pressure, the size and speed of the fan, the air pressure and volume of air in cubic feet per minute. The power required by the hoisting engine can be figured from the work being done and checked by the size and speed of the engine and the steam pressure available.

"When it comes down to facts each mine or group of mines served by the power plant presents different conditions. If one mine were supplied with power from its own steam plant and the mine closed down the overload charge against the power output would be greater than where several mines are served by the same power plant, unless all of them were closed down at the same time."

"But are there not cases where purchased power would be more economical than if it were produced at the mine?"

"I'll admit that there are; it depends largely upon the load factor, which is the ratio of the average use of the equipment required to meet the maximum load conditions. You will realize that the daily load factor is higher than the monthly ratio, because during the month the average number of working days ranges from 15 to 20. This is due to market conditions, car shortage and labor troubles. Naturally, the annual load factor is lower than the monthly, and the small plant serving such a mine would necessarily carry a high fixed charge per kilowatt-hour. This condition is lessened if current is purchased."

"There is this much to say; if a central station can supply electrical energy at a certain figure, the modern isolated plant can produce it cheaper."

"Well, they do it in other fields and it is reasonable to assume that a mining proposition can do the same." Just then the car stopped near the Berwind-White Co.'s No. 10 colliery at Scalp Level. As we made our way toward the power plant, Hunter said, "The central-station man will tell you that the individual mine plant is usually located at the least favorable point, considered from an electrical standpoint—at the mouth of the mine. He will tell you that this is so because, as the mine is developed, the electrical center of the load recedes from the plant and the loss in the distributing system constantly increases. And he is right in that also, because it will be necessary to either increase the size of the copper transmission lines or to operate with low voltage at the point of delivery.

"He does not mention that it is a comparatively simple matter to put in an alternating-current generator and transmit electrical energy to a small substation where the energy can be transformed to direct current for use in the mine. If current were purchased it would be necessary to send it to the motors in the mine as direct current, which would mean that a motor-generator set would have to be purchased."

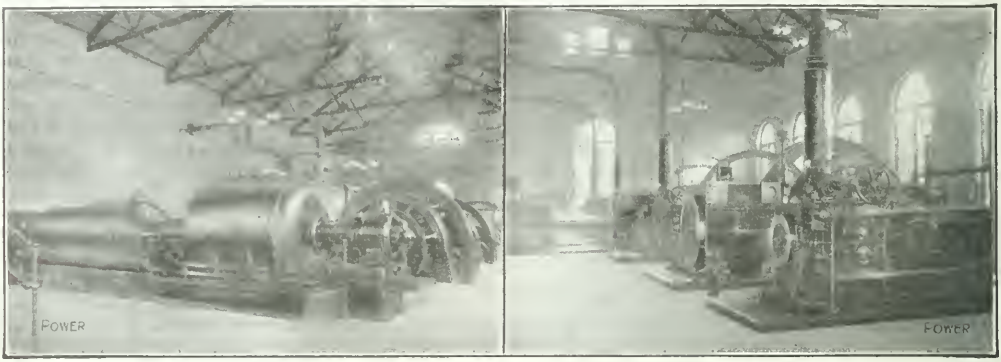

Fig. 2. Two Views of the Power Plant Operating the Scalp Level No. 10 Colliery

We had by this time reached the power plant (Fig. 2) in which a 300-kw., 550-volt generator, driven by an 18- and 42- by 32-in. cross-compound engine was operating. This unit supplied electrical energy to motors, etc., operating in the mine close at hand. For distant transmission there was a 1000-kw. turbo unit generating three-phase, 25-cycle, 6600-volt current, which was transformed to 13,000 volts for distant transmission. Here was a situation that had been met, as Hunter had suggested, without serious line losses and low voltage at the terminal points.

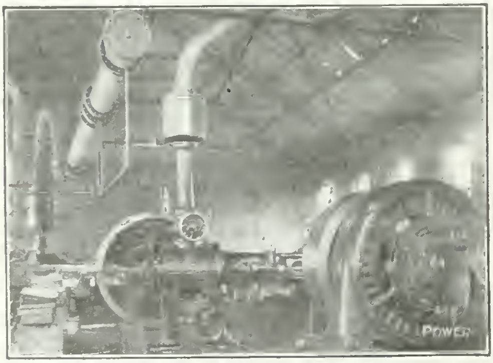

Fig. 3. Plants Are Operated with Bare Pipes, Leaking Joints and General Disorder

There were also two cross-compound 20- and 48- by 36-in. air compressors which at 75 r.p.m. delivered air to the mine at 75 lb. pressure.

"You see," said Hunter, after we had looked over the plant," that this outfit is flexible in that it takes care of short and long-distance transmission of electrical energy, which permits of placing alternating-current motors driving direct-current generators at points where they will give the best operating results, and which can be easily moved as mining conditions change. If the mine is not gaseous, there is no reason why the substation could not be underground."

"Rather a damp place for high-tension electrical apparatus?" I suggested as we turned to leave the plant. "I should think there would be trouble with burnouts."

"Yes, that's so. I remember one case where the roof fell in on the apparatus and put the mine out of service. A brick lining was built to prevent a recurrence of similar trouble. This lining sweated so and the apparatus became so wet that there were frequent motor burnouts. This trouble was partly overcome by putting a wooden lining inside of the brickwork."

"It seems strange that several small operators do not combine and build their own central station and meter the current consumption of each operator; then each operator would pay his proportional part of the operating expense."

"Yes, I've wondered why they do not get together, but they don't. Most of them go it alone and operate their plants with bared pipes, leaking joints and general disorder (Fig. 3), even though they are less than half a mile from the next mine. It could easily be done by each operator sharing in the expense in proportion to the tons of coal mined and the amount of current consumed."

Just then the car turned a corner and we were back at the hotel in time to pay our respects to the supper table.

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Thermometer and Mercury Column Reading—Whenever possible, a thermometer should be installed to give the temperature of the exhaust steam, as this temperature can be used as a check on the reading of the mercury column, but the pressure shown on the mercury column does not correspond to the exhaust steam temperature according to the regular tables of pressure and temperature relations of saturated steam. The thermometer reading will always be that corresponding to some pressure lower than the mercury column reading. This difference is due to the fact that there is always some air mixed with the steam entering the condenser and the condenser pressure is the sum of the vapor pressures of both the air and steam present. The temperature reading for the exhaust, however, will be that corresponding to the vapor pressure of the steam alone. The relation between the relative amounts of air and steam and their respective vapor pressure is one of direct proportionality of the relative volumes of the two to their separate vapor pressures.

Editorials

Interrupted Service

Electrical accidents such as that which recently paralyzed a large section of Cleveland's business district, should serve as a warning to managers who may be tempted to abandon their own plants in favor of central-station service. This is only one of a number of like instances during the past few years, and if they continue, a revision of the usual central-station solicitor's arguments would seem in order. While the occurrence is deplored and the Cleveland Illuminating Co. is to be commended for its prompt efforts to restore service, still the fact remains that business suffered heavily and several thousand were rendered idle, not to mention the inconvenience.

It would be foolish to contend that either the central station or the private plant is the more liable to interrupted service; but an accident to the former has a more farreaching effect. and the latter, with breakdown service as a safeguard, provides ample security against almost any contingency.

Striking contrast was offered between Cleveland's two largest hotels, the Statler, on central-station service, and the Hollenden, which has its own generating plant. In the former there were no elevators running and the guests were compelled to climb to their rooms and dress by candle light. Moreover, the upper floors were without water. On the other hand, everything went on as usual in the Hollenden.

⁂

A Boomerang

A member of the American Society of Mechanical Engineers, whose name is intimately associated with the word "efficiency" in magazine and other advertising matter, aspires to reform that body. Perhaps it is unfair to suggest that the motive is—publicity for himself—but a suspicion of that is strengthened by the fact that there is nothing in this instance to reform. Be that as it may, we have no quarrel with those who seek honors of the kind, but we submit that when one hopes to be carried into a position of favorable prominence on a wave of discontent he should be sure that there is water enough to float him across the flats. To begin with, it would seem most *efficient* to first investigate the existence or nonexistence of the conditions one is going to criticise.

There would have been time for a little of this even between Nov. 21, the date of an open letter to the managers of the society, printed and circulated among members, and Dec. 15, when one was addressed directly to the latter. The first was an indefinite protest against the present conduct of the society's headquarters and social affairs that amounted to a threat to "start something." It was so sagaciously worded that there was still chance to drop the matter, if the vaccination with the virus of dissatisfaction did not take on the body of the members at large.

Apparently the letter writer's own enthusiasm deceived him into thinking that he had a following, for in his second epistle he says that he had far more answers than he expected (which was modest—that he got any, surprises us; still, in any crowd, there are always some of a combative disposition, typified by the Irishman in a strange saloon who begged to know if the riot going on in the rear was a "private fight"). Further, he states that the proportion of answers from those sympathizing was over 90 per cent. We would have anticipated a full hundred per cent., for we are amazed that any but the said parties of a combative disposition would have taken the first screed seriously enough to reply to it.

Then he proceeds with his bill of particulars as to what he wants different in the running of the society, including under greater facilities for members at headquarters, rooms for transacting temporary business, writing and study facilities, stenographic and typewriting service, forwarding of mail, a dressing room, and a research bureau to consult books, pamphlets and periodicals in the library for members. If it had occurred to him to ask someone he might have learned that every one of these privileges is now among the numerous others at present enjoyed by the members who come around and take advantage of them.

Next he proposes "a small increase in annual dues to members residing within commuting distance of New York." From this we see that he has about 17 years the better of Washington Irving's hero of the Catskills, for Rip slept for 20 years, and it was only three years ago that the society considered an amendment to the constitution providing for an increase of three dollars per year to the dues of all New York members, which, when it was later put to vote, was lost.

We think we recall why he missed this, for, if we are not mistaken, it was on the occasion when this amendment was being discussed that he flounced out of the meeting in disgust after arising and asking when they were going to get to the professional papers; that he came there for the purpose of hearing and discussing them, and that the members at large were not concerned with the troubles of the New York members. Evidently he has awakened a tardy interest in the latter, howbeit it is rather inconsistent. The intent of the amendment was to care for our friend's final recommendation:

"A recognition of the social values of the society by definite entertainment once a year of outside members and their families. A simple luncheon to visitors on the days of the annual meeting and a formal reception, dance and supper."

At one time all of these were furnished free of charge to the out-of-town members, a part of the New York members paying the bills. To be exact, about 10 per cent. of the local members contributed, which obviously was unfair when, if all would do their share, $3 a man would be enough. It was to correct this injustice that the amendment was proposed, and the loss of it brought about the present "pay-as-you-go" plan whereby everyone, resident or nonresident, pays his own way to the dinner and dance and buys his own lunches. (The president's reception is financed from the society's treasury.) The new way has approval, especially from members from outside of New York who feel that every year is too often to impose on the New York members' hospitality (the annual meetings being always in New York), while they return the compliment not oftener than once in 10 years, if at all (the semi-annual meetings being held in other cities). But all of this is ancient history to those who keep in touch with the society and know what it is doing.

This society is not perfect any more than any other, and there are some things about it which might be better, but it is only those who are too busy to get around to the meetings who have the temerity to think they can improve things. Ignorance is often the foundation of courage. It takes those who have no children to tell others how to raise theirs.

All things considered, the society is as well managed and its privileges and facilities are as complete as can be expected. The great majority of the members concur in this belief and no individual will increase his popularity by attacking the present methods without offering tangible ways of improving them. Even then he can do it more *efficiently* by adopting the usual and more courteous course of submitting his suggestions to the council. Anything else is tactless.

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Yesterday and Tomorrow

How many engineers realize that over eighty per cent., say four-fifths, of the failures each year in the business world are attributed to the shortcomings of those who failed and that the remainder are due to causes apparently beyond their control?

Probably the same ratio of failures of engineers to make good will hold in the steam-engineering field. The causes may be incompetence, inexperience, neglect of duty, doubtful habits and dishonesty.

An incompetent engineer is a dangerous person in any engine room, and although employers are paying more attention to the qualifications of the men they put in charge of their power plants—because they are learning that economy in operation is essential in many instances to success—there are those who have not learned the lesson and, when a vacancy occurs, will engage almost anyone who happens along looking for a job.

When an incompetent man is in charge of a steam plant, anything is likely to occur, from a boiler explosion, or a wrecked engine, to burned boilers and bearings, scored cylinders and other power-plant mishaps which can be and are avoided by engineers who know their business.

An engineer may have had years of experience, and still be incapable of coping with the conditions existing in the plant of which he may have charge. Experience does not always make a man competent. Lack of judgment, inability to decide quickly in an emergency, and allowing matters to go from bad to worse are characteristics of an incompetent engineer.

Inexperience does not prevent a man from attempting to do work for which he is inclined, but it should prevent an engineer from occupying a position he cannot fill with intelligence and ability. It is a simple matter to operate a fifty-horsepower boiler, a slide-valve engine, an injector or a small feed pump. It is a different matter to operate a condensing plant of several units and complicated apparatus. While the inexperienced engineer might worry along in the small plant, he would be a failure in the larger one.

Negligence counteracts ability and experience and will result in an unsuccessful career. The tendency to put off doing things is characteristic of most men and retards their progress in proportion to the extent it is practiced.

The beginning of a new year is almost here, and while most of the resolutions made at that season are soon broken and cast aside, it is not a bad idea to resolve to do better, especially where known deficiencies exist. Looking back at the performance of yesterday is only useful as an object lesson of what might have been done, because most yesterdays are punctured with failures of some kind. Today there are problems which may be solved. Perhaps the mistakes of yesterday have taught nothing, or it may be that they have made a deep, lasting impression; it all depends upon the man.

But what of tomorrow? A few days ago millions of dollars were lost with the burning of the factory of Thomas A. Edison, now sixty-seven years old. According to reports, borne out by action, Mr. Edison did not stop to think of the past. Even while the fire was at its height, he was thinking of what he was going to do tomorrow. The next morning workmen were busy preparing to rebuild the works.

Do you get the idea? Yesterday and today are of the past and present, tomorrow is of the future, and is full of opportunities, except for the engineer who is satisfied to continue incompetent and neglectful.

A dishonest or grafting engineer will soon run his race and be discredited in the end. No employer will continue to employ such a man after his true character is known, and deep down in his heart the grafter knows that he is held in contempt by his fellow men.

A man's habits have much to do with his success. No engineer can carouse all night and be at his best the next day. If the truth were known, many preventable accidents have occurred while a man whose brain was clouded from the effects of the night before was on duty.

Even if criticism of a serious nature is not in order, it is worth anyone's while to look ahead with the idea of accomplishing more in his line of endeavor and not to be content unless he is steadily improving.

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"It is a reflection on any city when its merchants have to build 'white ways' to light the chief thoroughfares properly, themselves shouldering the expense," says the *Electrical World*. City lighting is paid for by the citizens in their taxes; the merchants pay for their private lighting out of the profits derived from selling to the citizens, so what's the difference? The poor dear public is always the one that pays the freight in the end anyhow. If the city did all the lighting, the enterprising merchants would have no opportunity to out-illuminate their rivals. We cannot work up a great amount of sympathy for the merchants in this regard.

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Take the impression received from gazing on the picture at the bottom of page 913, raise it to the *n*th power and you will begin to have a slight conception of what the present European war means to industry alone. Such destruction consequent upon accident is lamentable enough in individual cases. It is appalling when one thinks that the ruins here pictured are but typical of many more and all brought about deliberately.

Correspondence

Centrifugal Effect on Belts

On page 690, Nov. 10, W. F. Schaphorst treated certain idlers on belt drives as though they were something new, but compressor builders have long used them.

To test their efficacy, the Ingersoll-Rand Co. equipped a machine in its power house, some four years ago, and their performance was closely observed for about a year. As a result they have been adopted as standard design under the name of the "Short-Belt Electric." The compressor builder sought this means in order to solve the limited-floor-space problem, but this is not considered the only advantage, as the illustrations will show.

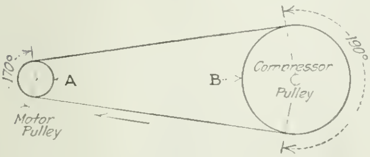

Fig. 1. Long Belt without Idler

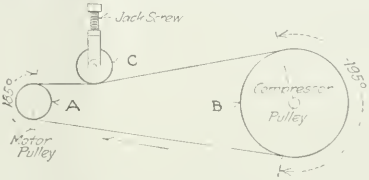

Fig. 2. Fixed Idler

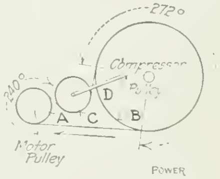

Fig. 3. Short Belt

Fig. 1 is the ordinary belt drive, in which the distance between centers of pulleys must be sufficient to give a reasonable arc of belt contact on the motor pulley, which at best never exceeds 170 deg.

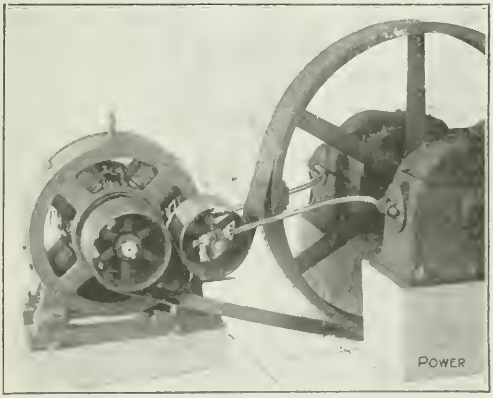

Fig. 4. Short Belt with a Floating Idler

Fig. 2 is sometimes resorted to when Fig. 1 fails to work satisfactorily. A tightener pulley *C* is placed between the pulleys *A* and *B* and held firmly against the belt. This increases the arc of contact on the motor pulley to 185 or 190 deg., but it also increases the belt tension, which is undesirable.

Figs. 3 and 4 show the short belt drive. This consists of the driving pulley *A*, the driven pulley *B*, and an idler pulley *C*, which is placed on the slack side of the belt close to the driving pulley. The idler pulley is carried on arms swung from the compressor frame and is free to raise and lower, or floats on the belt.

While the idler pulley is light, its weight is sufficient to take up the slack and hold the belt against the driving pulley. When the tension on the tight side of the belt increases and lengthens the slack side of the belt, the idler pulley immediately lowers, taking up the slack and at the same time wrapping the belt further around the driving pulley and giving a greater arc of contact. The belt contact is increased rather than the tension.

Most belt-transmission losses come from slippage or from excessive tension. With the short-belt drive there is no initial belt tension and but little slippage. When the motor is stopped the belt has no strain, and only the strain of the effort while in motion.

It will be seen from the foregoing that this form of idler has long passed the experimental stage.

Charles A. Hirshberg.

New York City.

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Reciprocating-Pump Slippage

The Nov. 24 issue contains an article on "Calculating Pump Slippage," by J. C. Hawkins. His method is one advocated by many writers, but I believe it gives results that are not only misleading but which may be incorrect. Briefly, the method is to tap a one-inch pipe into the discharge line of the pump and run this small pipe to a barrel on a scales or to a tank of known capacity. Then close the main discharge valve on the pump and let the water flow through the one-inch line to the weighing apparatus, running the pump at such speed as to maintain the water pressure at the regular working pressure. The slippage can then be computed by calculating the theoretical displacement and subtracting from it the actual displacement of the amount of water pumped.

The objection to this method is based upon the following:

Experiments conducted by the writer, the results of which were summarized in Power about two years ago, show that the slippage of a reciprocating pump is dependent upon two factors; namely, discharge pressure and piston speed. For a given pressure, curves were drawn showing the relation between piston speed and slippage. These curves reveal that at slow speeds the percentage of slip is very high, it being above 80 per cent. in many instances. With an increase in the speed of the pump the slippage decreased rapidly until the pump reached approximately its rated speed, after which the curve became quite flat—in other words, the percentage of slippage became nearly constant.

From the foregoing it can be seen that any method of determining slippage is incorrect if it entails the running of the pump at a speed other than its regular working speed. The amount of error which might be encountered depends upon the difference between the testing and the running speeds.

If in testing, the pump is run at a relatively slow speed, the percentage of slip will be extremely high. Proof of this will be found in the fact that any pump can be run at a speed so slow that no water will be pumped at all.

One concludes that when conducting slippage tests it is important to reproduce as nearly as possible the operating conditions of pressure and piston speed, the latter being by far the more important.

MERVIN K. BAER.

Chicago, Ill.

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Replacing Valves in Triplex Pumps

A short time ago I saw a tool for holding in place the springs on a pump valve where the valve chests open at the side and there is no room to hold the spring down with one hand and start the nut with the other. I always press the spring together and tie it on each side; then it can be dropped in place and the nut put on without difficulty, after which the string is cut to release the spring.

C. H. LLOYD.

Montreal, Canada.

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Calculating Pump Slippage

The article on this subject by J. C. Hawkins, in the Nov. 24 issue, is misleading. The 1-in. pipe serves no useful purpose and the trouble of putting it in and weighing the water in barrels might as well be saved. Furthermore, the percentage of slippage, calculated by this method, would not be the percentage of slippage at normal or any other speed except that of the test. In fact, this method, when used on a large pump, would give a slippage of about 90 per cent. when at normal speed it was about 10 per cent.

Blank off the main discharge pipe, run the pump as stated by Mr. Hawkins so as to maintain normal pressure, count the number of strokes per minute and divide by the number of strokes per minute when the discharge valve is open. The result is the percentage of slippage with the discharge valve open. In this way the approximate percentage of slippage at any speed is readily calculated.

Mr. Hawkins also makes the mistake of saying that the slip would be greater at high than at low speeds. The opposite is apt to be the case—in fact, the slippage sometimes becomes zero or even a negative quantity at high speeds due to the inertia of the water. In other words, at high speed, the pump may actually deliver more water than its piston displacement. For this reason the only accurate method is to measure the actual amount of water delivered. A good approximation may be made by blocking the piston, removing a check valve on one end of the pump and metering the water from the drain pipe on the other with the discharge valve open and with full pressure on the pump. This will give the quantity of slippage if the drain pipe is large enough to take care of it. The piston should be blocked in several positions and the average taken.

GEORGE L. SULLIVAN.

Santa Clara, Calif.

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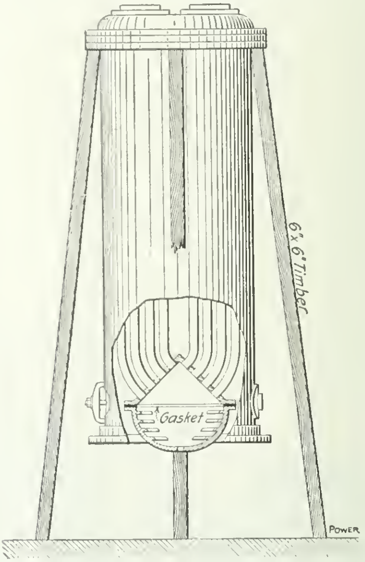
Putting Gasket in Heater

I once put a gasket in the flange of the oil separator compartment of the closed feed-water heater shown. As we were not prepared to lift the tubes out we had to do the job the following way:

First, we secured four pieces of 6x6-in. timber that were 8 in. longer than the distance from the floor to the flange at the top of the shell. With four jacks we raised the heater 4 in. and put the 6x6-in. timber in place, nailing on braces and otherwise securing them so that they could not slip.



HEATER RESTING ON TIMBERS WHILE GASKET IS RENEWED

Then the four stands or legs were taken off, the jacks put in their places, all the bolts taken out of the bottom flange, and the bottom head lowered with the jacks and slid out of the way.

As the nuts of the separator flange could not be turned, we twisted the bolts in two, as they were all rusted through and about ready to break. We cleaned both faces and cut the gasket and stuck it to the bottom face with shellac. Soon we found that putting our work together was more difficult than the tearing down had been. As there was no room for all the bolts, we put in what we could and tightened them. Then we proceeded to find a way to finish the job.

A large manhole for cleaning purposes was near the bottom of the shell. We cut three more openings 3 in. high by 8 in. long. This gave the required room to put in all the bolts.

Next, the heater was given a cleaning and the bottom head put on, after which the shell tubes and all were lowered on the stand. Three-eighths-inch boiler steel coverplates were made to fit over the holes we had cut in the shell, the plates being held with half-inch capscrews. These holes proved to be handy for cleaning, as we could get to all parts of the heater with a scraper and rake the scale out that lodged between the tubes.

A. G. Solomon.

Chicago, Ill.

Firebrick Mixtures and Refractories

In reading the articles by Mr. Monnett I have noted one apparent omission, the dutch-oven furnace or combustion arch over the furnace, with which I have had considerable experience.

On testing many different mixtures of firebrick and refractories in our laboratory, I have found that there are certain mixtures that will stand up better than others. Again, a flat arch that is practically level will not stand up as long as one having its height increased uniformly from the grate as it extends toward the bridgewall. I have laid this to the fact that the hot flames and gases impinge on the flat surface and are not carried away rapidly enough.

I would like to know what experience others have had along these lines and if they have made any tests of the refractories used.

A. E. Walden.

Baltimore, Md.

A Handy Spray Pump

A sprayer which can be used for many purposes about the power plant is shown in the illustration. It is made of a bicycle foot pump of the desired size and an aluminum gas-burner tip fastened with a small piece of copper wire. The wire is wound around the threaded spout of the pump on which the rubber tubing is usually attached, and the aluminum gas tip is then screwed over the wire and spout, the wire serving to keep it securely in place. The pump washer should be reinforced with several others to avoid leakage.

Spray Pump in Action

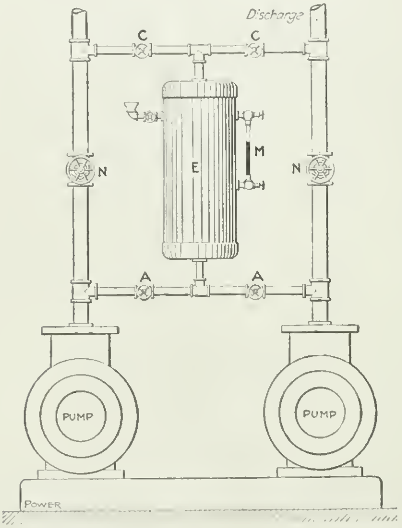
The sprayer is filled by placing it in a pail of water, disinfectant, or whatever is desired and the handle drawn back; the handle is then pushed ahead with sufficient force to suit the conditions. The spray will be a wide, fishtail-shaped thin sheet and will cover a distance of 40 ft. without difficulty. The width of the spray is approximately 3 ft. The sprayer can be put to a variety of uses, and in places that are usually inaccessible.

A. P. Connor.

Washington, D. C.

Boiler-Compound Feeder

The illustration represents a good form of boiler-compound feeder, where *E* is the body and *M* the glass gage, the merit being that the compound does not pass through the pump. The feeder can be readily regulated or cut out by valves *N*, *C* and *A* while the pumps are in operation.



Compound Feeder Connected to Two Pumps

C. R. McGahey.

Baltimore, Md.

Blanking Pump Valves

It is sometimes necessary to resort to extreme measures to keep machines in operation. Blanking pump valves or valve openings is one of them. Replacing a pump valve or valve seat may be done without much loss of time if the new parts and tools are at hand, but when the threads in the valve deck are gone it becomes more difficult. If the pump is urgently needed, the opening must be blanked off as a makeshift.

In putting a blank in the discharge deck a bolt may be fished in by a string let down through the spindle opening and tied to the end of a bolt with a heavy washer large enough to anchor firmly to the ribs on the bottom side of the deck. The bolt is then drawn up through the hole until it can be grasped by the hand from above. Another heavy flat washer is then placed upon the bolt and a nut put on and drawn up as tightly as possible and secured with a locknut. The course described cannot be followed if the bottom of the deck is inaccessible.

An anchor plate must be provided in such cases, having an oblong bolt hole in the center and be long enough to reach across and catch firmly upon the ribs on the underside of the deck, and must be narrow enough to go down through an opening in the valve seat. With a strong string looped around the bolt just below the thread and then given a half-hitch or loop at the end of the threads, the bolt is to be let down through the hole into the suction chamber, pulled up, and the upper washer put on as described.

I am not advocating this as a permanent repair, but useful in an emergency.

Edward T. Binns.

Philadelphia, Penn.

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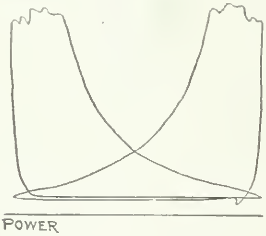
Ammonia Diagrams for Comment

The accompanying diagrams were taken from an ammonia compressor, with 9x18-in. cylinder, and running at 60 r.p.m. The head pressure is 200 lb. and the back pressure is 20 lb.; a 150-lb. spring was used in the indicator.



Ammonia Diagrams for Comment

I would appreciate reading the comments of readers on these diagrams.

Charles Mugler.

Schulenburg, Texas.

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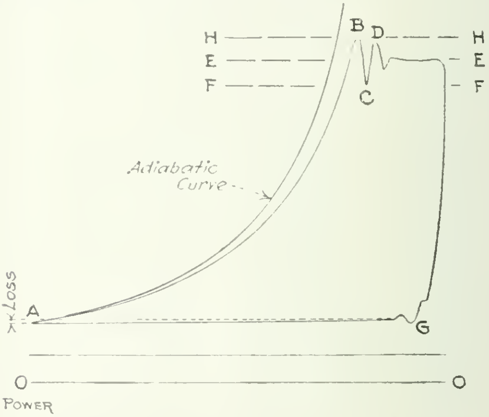
More Discussion of Ammonia Diagrams

Relative to the ammonia-compressor diagram shown in the Oct. 13 issue, it does not seem to me that Mr. Losh's criticism in the Nov. 17 Power is warranted. Herewith is another diagram taken at the same time from this compressor, nearly a duplicate of the one under discussion. The adiabatic plotted shows nothing seriously wrong with the compression which extends from *A* to *B*. During the suction stroke *GA* and the compression stroke *AB*, the discharge valve was closed, with greater or less pressure holding it shut. It stuck to its seat and did not open until *B* was reached.

The gas in the discharge pipe meanwhile was slightly reduced in pressure by the passage of part of it into the condenser, so that when the discharge valve opened at *B*, the gas in the cylinder rushed out against a lower pressure than the average condenser pressure. The average head pressure was *EE*, not *FF*, as Mr. Losh supposes. When *C* was reached, the condenser pressure closed the discharge valve and the pressure in the cylinder was built up to *D*, the valve again sticking, but not so tightly as before, as its period of closure was not so long. At *D* the pressure in the cylinder opened the valve again and the gas passed into the discharge pipe more uniformly.

The little peaks and valleys *BCD* in the discharge line are usual with some compressors and are caused by the chattering and sticking of the discharge valves.

If the cock used to throttle the gas to the high-pressure gage is opened, the gage pointer is seen to vibrate considerably. The inertia of the gage parts "irons out" these vibrations and does not allow the pointer to show the true ranges of pressure in the discharge pipe. The indicator shows these variations more accurately. This rise and fall of the pressure in the discharge pipe indicates that the discharge valve is open until *C* is reached, even though *C* is lower than *EE*. The pressure on top of the discharge valve is not constant.



Ammonia Diagram with Adiabatic Curve

From this diagram I can find but one fault with the compressor. The pressure at the end of the suction stroke (at *A*) is less than at the beginning. This is caused by the heavy suction valve in the piston—the machine is of the vertical, single-acting type—closing itself by inertia at the end of the suction stroke, thereby causing a certain amount of wiredrawing, and reducing the capacity of the compressor. The capacity is approximately proportional to the absolute suction pressure at the end of the suction stroke. This wiredrawing is more pronounced than usual, owing to the high speed at which the machine was running. With this type of compressor, as the piston is at the top of its stroke, and reverses its direction, the suction valve tends to open itself by its inertia, allowing the gas to enter the cylinder. As the piston slows up at the bottom of its stroke, the valve tends to close by inertia, thereby cutting down the pressure in the cylinder at the end of the suction stroke and reducing the capacity of the compressor. This loss is shown at the toe of the diagram.

The whole subject of compressor indicator diagrams is interesting, but too great reliance should not be placed on them, for the quality of the suction gas, the internal heating and the discharge temperature play important parts in the performance of the compressor and are not shown on the diagrams.

G. H. Crawford, Jr.

Philadelphia, Penn.

Engineers' Study Course

Problems in Power-Plant Design--XI

Water Supply and Fire Protection

An important detail to be considered in the design and construction of any steam power plant is an ample and never-failing supply of water. The uses for which water must be provided in a plant of this kind may be included under boiler feeding, condenser service and fire protection. The supply for boiler feeding in noncondensing plants may be based on

$$\frac{34.5 \times 1.2}{8.3} = 4.98\ \textit{gal.}$$

per boiler horsepower per hour, which allows for 20 per cent. overload. This, in round numbers, is 5 gal. per hp.-hr., and will cover all usual extras in the average plant.

The amount of cooling water required for condensing purposes will amount to approximately 30 lb. per pound of steam condensed for jet or barometric condensers, and 35 lb. for surface condensers for summer service in plants employing reciprocating engines working on an average vacuum of 26 in. In the case of turbine plants maintaining a vacuum of 28 in. this amount should be doubled.

With a condensing plant arrangements are commonly made so that the boiler feed, or at least a portion of it, is taken from the condenser, thus either eliminating or reducing this item when computing the total amount to be supplied. When a surface condenser is used, and the condensed steam is pumped back to the boilers, fresh water equal to only about 10 per cent. of that required by the boilers need be supplied. Or, when the condensing water is of good quality and allowed to go to waste, the entire boiler feed may be taken from this and no extra supply need be provided.

When determining the quantity of condensing water, Table 1 may be used as it gives the pounds of exhaust to be condensed per indicated horsepower-hour for different types and sizes of engines and turbines. The figures in this table assume that 10 per cent. of the steam supplied to the engine or turbine is condensed in doing work and by the various losses due to radiation, etc. In other words, they represent 90 per cent. of the actual water rates.

TABLE 1. WATER RATES—10 PER CENT.

Type and Size of Engine	Lb. of Exhaust per I.Hp.-Hr. to Be Condensed
Simple, high-speed	22
Compound, high-speed	18
Compound, four-valve	15
Compound corliss, over 500 hp.	13
Turbine over 500 hp.	12
Turbine over 1500 hp.	11
Turbine over 3000 hp.	10

The modern fireproof power house requires but little in the way of fire protection, but in case it forms part of an industrial plant, a system of hydrants and sprinklers usually must be provided. Unless the local rules require a different treatment, 250 gal. of water per minute at 90 lb. pressure should be supplied for each $1\frac{1}{8}$-in. fire nozzle, and the same amount for each 60 to 70 sprinkler heads. The arrangement for the sprinklers should also be such that they will operate automatically for at least one hour.

Sources of Supply

The most frequent sources of supply are natural ponds or lakes, artificial reservoirs fed by springs or small brooks, running streams of good size, artesian wells and city or town mains. Natural ponds and lakes, provided they are of such size as not to be seriously affected by dry seasons, form a valuable source of supply, especially if they are so situated that the water may be easily raised to the level of the power house, or, better still, may flow to it by gravity from a higher elevation.

The value of artificial reservoirs fed by springs depends largely upon their stability. These should not be relied upon unless the supply for each twenty-four hours during the driest season is somewhat in excess of the plant requirements for the average working day. Supply and demand can be equalized to a considerable extent by the use of a storage reservoir of suitable size, so that water may be saved during the night when the plant is shut down. Running streams which never fall below the maximum requirements of the plant are to be classed with ponds and lakes, provided they are conveniently located and the water is of fairly good quality. In certain cases artesian wells may form a reliable source of supply. Their flow varies so greatly in different localities that general data concerning them are of little practical value. Figures at hand give for a 6-in. well sunk to a water-bearing stratum 10 ft. in thickness, with the water level lowered 1 ft. by continuous pumping, a capacity varying from 170 gal. per hr. for fine gravel without sand. In New England and similar rocky localities the flow will be much less.

Bringing the Supply to the Plant

When the plant is supplied from a pond or reservoir at a higher elevation than the power house, the water may be brought directly to the pumps by means of a gravity pipe line. If from a pond, reservoir or river at such an elevation below the power house that the lift, plus the friction head in the suction pipe, does not exceed 15 to 18 ft., a power pump of some form may be used and located in the power house. With sources like the above, but with a total lift greater than 18 ft., the same type of pump may be used, but it must be placed at such a point that the suction lift will not exceed 18 ft. With sources like the above but with an abundance of water and so located that the pump can be placed at a lower level than the source of supply, a hydraulic ram may often be used to advantage. Artesian wells require a special deep-well pump or pneumatic air lift.

Type of Pump

Direct-acting, steam-driven plunger pumps, power pumps, centrifugal and turbine pumps, driven by vari-

[illegible] kinds of motors, are adapted to this class of work.

Direct-acting steam pumps are convenient, easily regulated and cared for, and are often employed for this purpose when the conditions are such that they can be located in the power house and their exhaust utilized for heating purposes.

The principal objection to this type of pump is its large steam consumption, which may be taken approximately as follows:

Simple noncondensing	120 lb. per hp. per hour
Compound noncondensing	80 lb. per hp. per hour
Triple noncondensing	40 lb. per hp. per hour

Power pumps of the plunger type are also adapted to this class of work under certain conditions and may be driven either by steam or gas engines, electric motors or may be belted to a countershaft. Pumps of this type may be located at a distance from the power house and operated by an electric motor; this gives them an advantage over the direct steam pump under certain conditions. The chief disadvantage of this pump, under some conditions, is that it must run at a constant speed, but this is not an objection when it is used for pumping from a lake or a river into a reservoir. In case of boiler feeding and similar work, where close regulation is required, it is a disadvantage which must be considered. The centrifugal or turbine pump is especially adapted to the handling of large volumes of water under moderate heads, and is also constructed for high-pressure work when required.

This pump is simple in construction, requires practically no care and may be direct-connected to an electric motor or steam turbine, thus making a compact and effective unit. It has the same limitation as to speed as noted in connection with the plunger pump.

CAPACITY

The catalog ratings of pumps usually give the theoretical capacity, hence in estimating the actual capacity the slip or leakage around the piston and valves must be taken into account by multiplying by a factor depending upon the type and the size of the pump. Table 2 gives factors for this purpose.

TABLE 2. ALLOWING FOR PUMP SLIPPAGE

Type of Pump	Actual as Compared with Theoretical Capacities
Medium piston and plunger	0.85
Small piston and plunger	0.75
Large centrifugal	0.80
Medium centrifugal	0.55
Small centrifugal	0.35

POWER FOR DRIVING PUMPS

The actual horsepower required for driving a pump is given by the formula

$$hp. = \frac{W \times H}{33{,}000 \times E}$$

in which

$hp.$ = Horsepower required;

W = Pounds of water raised per minute;

H = Height of lift, in feed, including the friction head in both suction and delivery pipes;

E = Efficiency of the pump,

which may be taken as follows: Triplex power pumps, 60 to 80 per cent. for total heads of 100 to 300 ft. respectively. Centrifugal pumps of the best class, 50 to 70 per cent., depending upon size and conditions under which they operate.

The Clinkering of Coal*

By LIONEL S. MARKS

There is a growing feeling among large coal users that the important matter of clinkering ought to be taken care of in some way when making contracts for coal. It is frequently suggested that specifications ought to include the melting temperature of the ash as this has generally been assumed to determine the amount of clinker formed.

Before the subject of clinkering can be put upon a satisfactory basis, two kinds of measurement are necessary: (a) the determination of the extent to which the clinkering of a given coal is objectionable, and (b) the determination by a laboratory test of some characteristic of the ash which indicates the objectionableness of the clinker.

The important fact about clinkering is not so much the total weight or volume of clinker formed as the kind of clinker—i.e., whether nonadherent, easily broken up and easily removed, or whether it forms a pasty mass with the surrounding coal, or which runs on to the grate and freezes there as a strongly adherent but thin sheet.

It is probable that the only reliable basis at present for determining the "objectionableness" of the clinker is the judgment of fireroom observers. The writer has attempted to get a quantitative measurement by sifting the ashpit refuse into a number of selected sizes. In tests made with a Murphy stoker equipped with the usual clinker-breaker, the coals which gave most trouble were found to have the lowest percentage of smallest size clinker (less than 1 in.) and the highest percentage of the largest size clinker (greater than 2 in.) The differences between the percentages of the different sizes for good and poor coals is small, so that the method cannot be relied on.

The only kind of laboratory test on coal ash which would seem to be of value in indicating the probable extent and character of the clinker is one in which the ash is subjected to such temperatures as will cause it to melt. A number of attempts have been made to determine the melting temperature of an ash from its chemical analysis, but none has been satisfactory.

That valuable indications may be obtained from a knowledge of the iron and sulphur content of the coal or of its ash, is suggested by some recent tests of Palmenburg,† which, as pointed out by Bergwyn,‡ appear to show the following results:

An ash containing less than 10 per cent. of iron oxide (Fe_2O_3) does not fuse at a temperature below 2550 deg. F.; an ash containing more than 20 per cent. does not fuse at a temperature above 2550 deg. F.; for an ash containing between 10 and 20 per cent. the fusing temperature varies widely.

A coal containing less than 1 per cent. of sulphur does not fuse at a temperature below 2550 deg. F.; a coal containing more than 2 per cent. does not fuse at a temperature above 2550 deg. F.; for a coal containing between 1 and 2 per cent. the fusing temperature varies widely.

A coal containing less than 3 per cent. of iron oxide plus sulphur does not fuse below 2550 deg. F., and a coal containing more than 3 per cent. does not fuse above 2550 deg. F.

The determination of melting temperatures of coal ash is attended with many difficulties, the more important of which is in the definition of the melting temperature. When a coal ash is heated slowly, that one of its constituents which is the most fusible will be the first to melt. Its effect upon the rest of the ash will depend upon three factors: (a) the amount of that constituent; (b) its viscosity when melted; and (c) its chemical reaction on the remaining constituents. If there is much of this constituent the ash will become fluid to an extent which depends upon its viscosity. If the molten part is small in amount but very fluid, it may separate from the rest.

There is another factor of importance in connection with the behavior of molten coal ash, namely, its viscosity. A satisfactory laboratory test for clinkering should indicate viscosity as well as melting temperature. The only method used to any extent for this purpose is really an imperfect one of determining the temperature at which the material has a standard viscosity. This is accomplished by heating the material in the form of a Seger cone of standard dimensions, at a standard rate, until it has bent to some standardized final form. The cone has usually been set up vertically. The rate of rise of temperature is usually taken as 2 deg. C. (or 4 deg. F.) per minute and the melting temperature taken as that at which the tip of the cone touches the base. This method, it will be observed, does not give a standard viscosity unless the time from the beginning of bending is the same in all cases. It should be noted also that the temperature of the cone increases as the bending goes on.

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*From a paper read at the annual meeting, December, 1914, of the American Society of Mechanical Engineers.

†"Journal of Industrial and Engineering Chemistry," April, 1914.

‡"Journal of Industrial and Engineering Chemistry," August, 1914.

In tests by the writer with a standard rate of heating of 2 deg. C. per minute, the time taken for the cone to bend to its final position from the beginning of bending, has varied from 10 to 80 minutes; the final viscosities in these two cases are obviously different. It should be noted that even if this method gave standard viscosities, it would not necessarily give information of value on clinkering. If it were true that all clinkers became troublesome when they reached a certain lower limit of viscosity, and if that particular viscosity were chosen as the standard, one might expect a close relation between laboratory and fireroom results. It has not, however, been shown that there is a lower limit of viscosity of the ash which cannot be exceeded without trouble from clinker, and moreover, in ashes whose most fusible constituents are very fluid the Seger cone method fails as indicated below.

Notwithstanding these inherent defects, the Seger method appears to merit further investigation, but an important modification in its use seems to be advisable. In the standard method the cones are placed vertically. This gives satisfactory results with the original Seger cones and with many fire clays, but it is often unsatisfactory with more complex mixtures. If the more fusible constituents are very fluid they run down to the base of the cone and may leave the apex apparently unchanged in a vertical or slightly inclined position until it disappears; that is, the cone never assumes the standard final shape. J. P. Sparrow, of the New York Edison Co., has suggested placing the cones horizontally with the apex projecting over the side of the support. This method has been adopted by the writer as being more sensitive than the usual method and as giving indications which can be duplicated more accurately and are, therefore, more reliable. The temperatures noted in this method of testing are at the beginning of bending and when the apex of the cone points vertically downward.

Tests of melting temperature observations on samples of coal ash by two or more laboratories bring out the fact that widely different results are obtained with the same ash samples.

The more important factors influencing the melting point of the ash are: Nature of the surrounding atmosphere; size of the cone; position of the cone; nature of the binder; rate of heating; location of the cone in the furnace; and method of support of the cone.

Table 1 gives the melting temperatures observed in the two furnaces. The cones were in all cases vertical. The dates are those on which the coal (from which the ash sample was obtained) was burned under a boiler. It will be seen that the temperature difference ranged from 120 to 255 deg. C. (260 deg. to 459 deg. F.). It should be noted also that even the order of fusibility was changed in some cases when the atmosphere changed, and that the lower the fusing temperature in an oxidizing atmosphere the greater is the increase in fusing temperature when changing to a reducing atmosphere. The atmosphere in a boiler furnace is always oxidizing. Therefore, it is important that the cone should be surrounded by an oxidizing atmosphere.

TABLE 1. INFLUENCE OF ATMOSPHERE ON THE MELTING TEMPERATURE OF ASH CONES

Date	Melting Temperature Deg. Cent. Reducing Atmosphere	Oxidizing Atmosphere	Difference Deg. Cent.
Feb. 3	1560	1430	130
4	1580	1410	170
5	1580	1410	170
6	1605	1390	215
10	1620	1380	240
13	1635	1440	195
Mar. 3	1595	1440	155
5	1620	1365	255
11	1580	1400	180
13	1610	1445	165
17	1620	1500	120

The size of cone has an influence which is different for different materials. With Seger cones the difference is negligible. For example, a No. 16 Seger cone (17 mm. base, 70 mm. high) placed horizontally, has a melting temperature (initial and final bending) of 1355 to 1410 deg. C.; when molded into the standard size of Seger cones of higher fusing temperature (8 mm. base, 30 mm. high), the result is 1355 to 1420 deg. C. The size of the cone adopted in the writer's tests was 11 mm. base and 52 mm. high. One ash sample tested horizontally in a cone of this size gave melting temperature from 1425 to 1450 deg. C.; in a 13-mm. base, 57 mm. high cone, the temperature was from 1400 to 1430 deg. C. As is to be expected, the larger cones show a lower melting temperature, but the difference is not great.

The melting temperature (complete bending) of a horizontal cone is always less than for a vertical cone. The difference varies considerably and is less with the more fluid melts.

The ash is usually mixed with a 10 per cent. solution of dextrin before molding into cones. It was found, however, that water alone was satisfactory if the cones are not dried much before being put in the furnace. The effect of adding dextrin is generally negligible, but sometimes it increases the apparent fusing temperature (complete bending) by as much as 10 deg. C.

The rate of heating the cones has a marked effect on the apparent fusing temperature. Any increase in the rate results in increased lag of the pyrometer (Le Chatelier type with porcelain tube) and causes an apparent decrease in the melting temperature. Tests on the ash showed melting temperatures (complete bending) which were 40 deg. and 35 deg. C., respectively lower, with 6 deg. C. increase per minute, than with a 2-deg. C. increase per minute.

The location of the cone in the furnace is important; it should be as close to the pyrometric element as possible. The temperature at the front of a No. 29 Meker furnace was found to be about 20 deg. C. lower than that in the middle of the muffle. An additional door plate reduced this difference.

The cone must be supported on material unaffected by the highest temperature reached, and which does not react chemically on the ash cones. Plates of fused quartz have proved satisfactory. They have to be supported so as to permit circulation of the gases below them, to give them the same temperature as the rest of the muffle.

Another point of importance is the complete incineration of the ash before it is made into a cone. An appreciable amount of carbon remaining unburned tends to increase the apparent fusing temperature.

The writer used a Meker furnace in all of the later tests made in his laboratory. Holes were made in the back of the furnace for the insertion of the pyrometer, and in front for observation and for the insertion of a quartz tube through which a stream of air was introduced into the muffle to insure an oxidizing atmosphere. The furnace was heated rapidly to within about 200 deg. C. of the expected fusing temperature and the rate was then reduced to 3 deg. C. per min. and kept there. The observation hole was plugged except when in use. Observations were made through dark blue glass at 2½-min. intervals. The horizontal cones were supported only so far as was necessary for balance.

To find out whether fusing temperatures as determined by the method outlined have any relation to the amount of clinker trouble experienced in burning the coal, a series of tests was carried out on a boiler equipped with a Murphy stoker at the L St. plant of the Edison Electric Illuminating Co., of Boston. Fourteen tests were made, each of 24 hours' duration, with 10 different coals; five of the tests were made with one coal, and one test with each of the nine remaining coals. The conditions of all these tests were kept the same so far as possible. Each test started at 7 a.m., and a load of from 150 to 175 per cent. of the rated load was maintained until 5 p.m., when forced draft was put on and the capacity kept at 200 to 250 per cent. of rated load for 2 hours. The capacity was then reduced to from 150 to 175 per cent. till 11 p.m., when the fire was banked until 7 a.m.

Table 5 gives the results of tests of the ash and a statement of the extent of the clinkering for each of these tests.

It will be seen that there is a general relation between the two, but that it is not definite enough to be of much practical use. The coals giving the three lowest fusing temperatures are also those giving the maximum clinker trouble. Those ashes with a final fusing temperature of 1400 deg. C. (2552 deg. F.) or higher, gave little trouble, as did the ash, which melted at 1380 deg. C. (2516 deg. F.), while others which melted at 1395 deg. C. (2543 deg. F.) gave much trouble. The most troublesome clinkers had final melting temperatures of 1370 to 1375 deg. C. (2498 to 2507 deg. F.), which is practically the same as the temperature for coal that gave good results. It would appear then that the final melting temperature cannot be taken as a criterion in the range from 1380 to 1400 deg. C. (2516 to 2552 deg. F.), and the inference is that the uncertain region extends over a still wider temperature range. It is probably true that final fusing temperatures below 1350 deg. C. (2462 deg. F.) show a coal which would give clinker trouble under the conditions of the L St. station, and that temperatures above 1420 deg. C (2588 deg. F) indicate a coal comparatively free from such trouble, but further investigation would be necessary to establish that fact. The important thing, however, from the point of view of coal specifications, is that the tests of the ash of Feb. 3, 4, 5 and 6; Table 2, when the regular station coal was used which gave a minimum of clinker trouble, yield results which fall in the doubtful region and would, therefore, be rejected in coal specifications based on fusing temperatures alone. Tests made at the New York Edison Co.'s laboratory on ash having a mean fusing temperature of 1245 deg. C. (2272 deg.

[illegible] would from the experience of the New York Edison Co. Mr. Sparrow reports, "indicate serious trouble from clinker in commercial service. This remark applies to combustion on a Taylor stoker. Tests in Boston gave the same melting temperature for two coals, although one was found to give negligible and the latter excessive clinkering in actual use.

TABLE 2. MELTING TEMPERATURE OF ASH AND FIRE-ROOM RECORD OF CLINKERING

Date	Melting Temperatures, Deg. Cent. (Fahr.) Initial and Final Bending	Range	Amount and Character of Clinker
Feb. 3	1350-1395 (2462-2543)	45 (81)	Light
4	1360-1400 (2480-2552)	40 (72)	Light
5	1360-1400 (2480-2552)	40 (72)	Light
6	1340-1380 (2444-2516)	40 (72)	Light
10	1360-1375 (2480-2507)	15 (27)	Hard, excessive; 50 per cent. of grate
13	1350-1395 (2462-2543)	45 (81)	Excessive to moderate; large clinker
Mar. 3	1370-1420 (2498-2588)	50 (90)	Not much but very hard and isolated
5	1350-1370 (2462-2498)	20 (36)	Excessive; 75 per cent. of grate
11	1355-1380 (2471-2516)	25 (45)	Heavy
13	1340-1395 (2444-2543)	55 (99)	Heavy
17	1430-1480 (2606-2669)	50 (90)	Light
24	1420-1450 (2588-2642)	30 (54)	Very little
26	>1500 (>2732)		Light, hard
Apr. 8	1335-1370 (2435-2498)	35 (63)	Excessive, very hard, 18 to 20 in. in V and thick

Additional indications of the liability to clinker trouble may be obtained from the range of temperature during bending and from the appearance of the bent cone. The cones of the ash which gave most trouble had a very fluid constituent which ran down to the tip of the cone and also upon the supporting plate. It would appear that the most fusible constituents will separate from the rest of the cone, leaving a skeleton which does not bend until its own fusing temperature is reached—that is, with the kind of ash which gives most trouble, the Seger cone method fails as a result of the separation of the more fusible from the less fusible constituents.

It is possible to accept the appearance of the bent cone as a partial indication of the clinkering behavior, and it may be possible to predict the behavior of an ash from that indication combined with the fusing temperature. The range of temperature during bending may also possibly be used. There seems to be a close relation between this range and the viscosity of the melted cone. It should be noted, however, that there is a liability to error in observing the initial and final bending temperatures, when the range is not less than 10 deg. C., so that an observed range of 30 deg. C. may actually be anywhere from 10 deg. to 50 deg. C. It is necessary to make several determinations to get the range with reasonable certainty. The appearance of the melted cone is consequently more valuable than the range of fusing temperature.

The investigations of the writer seem to show that under the conditions of combustion at the L St. plant of the Edison Electric Illuminating Co., of Boston, a coal with a fusing temperature (final bending) below about 1400 deg. C. (2550 deg. F.) will probably give trouble if the ash has a fluid constituent, whereas it will not give trouble above about 1380 deg. C. (2516 deg. F.) if the ash is viscous. This conclusion would require further investigation with many other coals before it could be accepted even for this particular plant; naturally it cannot be applied to plants with different operating conditions.

It may be interesting to note here the conclusions reached by other investigators as to permissible fusing temperatures. Mr. Sparrow, in a report to the Association of Edison Illuminating Companies, September, 1914, states as a result of boiler tests with a Taylor stoker, using 13 different coals:

> It will be seen that the critical point of ash fusion lies between 2400 and 2500 deg. F. All coals where ash fusion temperatures are above 2500 deg. F. can be classed as nonclinkering (those below 2400 deg. F. as clinkering; using 2450 deg., therefore, as a standard, there is an allowable margin of 50 deg. F. above and below standard to cover possible errors in testing.

Most of his boiler tests lasted 120 hours. The ash fusion tests were conducted under conditions similar to those used by the writer. The fusing temperature is the middle of the range from initial to final bending of the cones. It should be pointed out that the fusing temperatures obtained in Mr. Sparrow's laboratory average about 260 deg. F. less than those obtained for the same ash in the writer's laboratory.

E. J. Constan, as a result of his investigations, finds that the melting point of coal ash varies from 1150 deg. C. (2202 deg. F.) to 1700 deg. C. (3092 deg. F.) and recommends the following ash-melting temperatures: For boiler coals, above 1400 deg. C. (2552 deg. F.); for locomotive and producer plants, above 1500 deg. C. (2732 deg. F.).

Centrifugal Pumps for Boiler-Feed Service*

Eight or ten years ago the use of centrifugal pumps for boiler-feed service was practically unthought of. In recent years, however, there has been considerable experimenting with pumps for small capacities and high heads, such as are encountered in boiler-feed work, and now the reciprocating boiler feeders have practically been eliminated from the more modern plants, where the capacities run over 1750 boiler horsepower.

One of the first centrifugal pumps of real commercial merit, if it was not the first, was that placed in a large paper mill. This plant had a boiler capacity of 12,000 boiler horsepower and the pressure was 140 lb. The boilers had been supplied by two compound duplex pumps of the outside end-packed type. The steam ends of these pumps were in bad shape, and by a weighed water test it was found that they were taking about 120 lb. of steam per water horsepower per hour. They had no use for this exhaust steam.

A short time before the company considered using a centrifugal boiler feed pump, it had put in a cross-compound condensing Corliss engine with generator, on which an economy of about twelve pounds of steam per indicated-horsepower per hour was obtained. Inasmuch as there was an excess of electrical power, it was decided to put in a motor-driven four-stage centrifugal pump designed for a capacity of 1080 gal. per minute against a total head of 380 ft., or 165 lb. A great deal of attention was given to the difference between the steam and the water pressures and this was figured low in order to make the units as economical as possible.

With an economy of 12 lb. of steam per indicated horsepower per hour, and with allowance for the engine efficiency and that of the motor and the pump, the centrifugal pump took about twenty-five pounds of steam per water horsepower per hour. This was a saving of about ninety-five pounds of steam per water horsepower per hour, or with the pump operating at its full capacity, a total saving of 9850 lb. of steam per hour.

Inasmuch as this pump did not operate continuously with full capacity (this was figured with a margin of safety of 50 per cent. over the normal rating of the boilers), it was assumed that a safe figure for the economy of the centrifugal pump would be not more than thirty-five pounds of steam per water horsepower per hour, or a total saving of about 8800 lb. of steam per hour, or 293 boiler horsepower on a 30-lb. rating.

At this plant there is a saving of approximately $10,000 per year on coal alone. Besides this saving, after the pump was installed it was found that there was also a saving on the fittings and valves as there was a complicated distribution system. The absence of the shocks almost eliminated the repair bill on this item.

The pump was installed with a head on the suction side of about six feet, the water handled being about 210 deg. F. No back pressure is carried in the heater. This pump has now been operating for eight years, and the only repairs were one thrust bearing and a set of wearing rings, or a total charge of about $100. The cost of the equipment was between $3800 and $4000.

The conditions in this case were somewhat peculiar in that there was a sufficient supply of exhaust steam for heating the feed water without the use of exhaust steam from the boiler feeders. In the ordinary plant, especially in a central station, the main units run condensing and the auxiliaries run noncondensing, using the exhaust steam for heating the boiler feed water.

A further advantage of the steam-driven auxiliary idea is that the boiler supply is not dependent on the continuity of current. In a station having but one or two electrical units, it is rather dangerous to make the auxiliaries motor-driven on account of the possibilities of a short circuit shutting down the motor and interrupting the water supply to the boilers. As the turbine uses no cylinder oil the heater gets clean steam and the boilers are not subject to oil trouble.

There is practically no limit to the size of a turbine-driven boiler feed pump, which can be built either in the lower or the upper scale. In other words, boiler feed pumps operate at a capacity as low as 10 gal. of water per min. against 250 lb. pressure and as high as 1600 gal. of water per min. against 280 lb. pressure.

The following rules are desirable to follow in connection with figuring on boiler feed pumps:

The normal rated capacity of the boilers is ordinarily taken and 50 per cent. added to that for the capacity of the pump. In other words, a 10,000 boiler horsepower having a normal feed of about 600 gal. of water per minute would be supplied with a pump having a capacity of 900 gal. per minute.

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*Excerpts from a paper by Edward S. Adams before the Ohio Society of Mechanical, Electrical and Steam Engineers, Columbus, Ohio, Nov. 19, 20 and 21.

The water pressure is ordinarily figured with a differential of from 25 to 30 lb. where the conditions cannot be closely approximated. This differential has been made as high as 60 lb., which is a departure from the general rule mainly on account of the prejudice of an operating engineer or water tender.

Where a turbine pump feeds more than one battery of boilers, and where it may obtain its steam supply from one battery and supply water to another, it is always specified that if the normal steam pressure should be 150 lb., the turbine shall carry its full load on as low as, say, 100 lb. pressure, and in some cases as low as 70 lb. This feature can be obtained by supplying auxiliary shutoff valves and nozzles, which are used only in cases of low steam pressures.

It is a good idea to get as much head as possible on the suction side of a centrifugal pump handling hot water. Ten feet is considered a good average, although there are some pumps operating with a head on the suction side as low as three feet. However, in these cases the conditions are rather constant, the load does not fluctuate much, and there is practically no possibility of entrained air being carried into the pump.

The mistake of buying the cheapest turbine-driven centrifugal pump offered is frequently made. While it will perform its work for a short time in the ordinary way, it soon deteriorates, as there really is not much more severe service on which centrifugal pumps can be used than that for boiler-feed purposes. The turbine also usually receives rough treatment, as in nine cases out of ten it is under the care of the water tender.

There are a few fundamental features in connection with centrifugal pumps in general, and centrifugal boiler-feed pumps in particular, which determine whether an installation is going to be satisfactory.

On account of the high pressures encountered it is important to provide removable bronze wearing rings on both the impeller and casing at the joint between the suction and discharge chambers. There should also be bronze sleeves over the shaft and removable stationary sleeves in the casing between the impellers. The impellers should be made of bronze in all cases.

On account of the possibility of the boiler pressure decreasing, which will decrease the pressure against which the pump is to operate, and because of the further fact that at this time there is ordinarily a great demand for feed-water to the boiler, as the steam pressure has likely been caused to drop by overload on the boilers, the pump should be so designed that, regardless of the head against which it is to operate, the horsepower taken by it will not exceed a certain predetermined amount. While this is especially true with motor-driven pumps, it also applies to turbine-driven pumps as a serious overload (due to the enormously increased capacities which are obtained on some designs of pumps when the pressure is dropped) sometimes destroys the turbine.

The points which make the centrifugal pump superior to the reciprocating are better steam economy, simplicity and ease of operation. It requires no expert to keep it up to the standard. There are no steam valves to be set, no indicator diagrams to be taken, and no valves or seats to replace. The impossibility of building up an excessive pressure insures no undue strains on the piping. In a properly designed centrifugal pump it is impossible to build up a pressure in excess of a predetermined head, known as the shutoff pressure, and beyond which the pressure will not go.

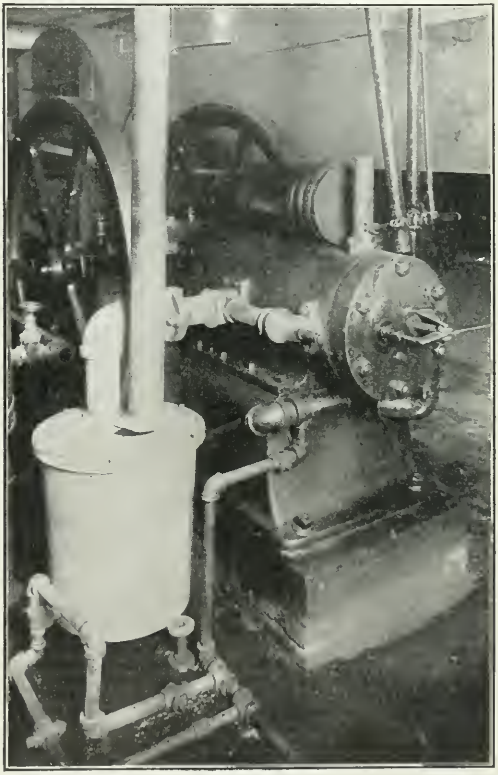
One of the more important points, however, is the absence of shock or pulsation. The pressure is built up gradually and when the boiler-feed regulator opens there is no hammer in the line, the pressure is always ready to force the water into the boilers without a pump governor and speeding up the pump. In case the water should become too hot or should not flow, there is no danger that the centrifugal pump will wreck itself. Another point is the absence of vibration; consequently light and inexpensive foundations only are required for such a unit—incidentally this means a small amount of floor space required.

Practically the only bar to the continuance of efficiency by a centrifugal pump is leakage back from one stage to another, or, in the case of a single-stage pump, leakage back to the suction side. The labyrinth rings are a development of years of experimenting, and it has been found that with this type of ring the leakage is practically nil. Of course, in water containing a certain amount of grit, there will be some leakage which necessarily grows worse as time goes on. In order that the pump may be brought back to its original efficiency, the only operation necessary will be to renew the labyrinth rings.

Peculiar Gas-Engine Accident

An accident to a gas engine at Public School No. 130, Brooklyn, produced the remarkable results shown in the photograph. This was a 15-hp. two-stroke-cycle engine, operating on illuminating gas with hot-tube ignition and belted to a ventilating fan. Hit-and-miss governing was employed and at the time of the accident the engine appeared to be running perfectly.

The bedplate cracked square across and buckled, jackknife fashion, enough to allow the piston to pull out of the cylinder and land on top of the latter, where it continued to reciprocate due to the flywheel momentum. This was the condition in which the engineer found it when he entered the room to close the throttle. After the piston had pulled out the bedplate settled back on the foundation. The only other damage was a broken piston ring, a broken exhaust pipe and water connection. Also, the governor rod snapped after it had been bent up by the buckling action of the engine.



Engine Showing Piston on Top of Cylinder and Broken Exhaust Pipe

The initial cause of the accident is a matter of conjecture, one theory being that water, due to condensation in the gas line, had come over into the cylinder in sufficient quantity to produce the effect noted. It might be mentioned in this connection that although there is a drain in the exhaust box there was none in the gas line close to the engine. Again it has been suggested that preignition may have been the cause. Comments on the probable cause are solicited.

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A Cement for Making Repairs on Switchboards when iron or other metal has to be fastened to marble may be made from 30 parts plaster of paris, 10 parts iron filings and ½ part sal-ammoniac. These are mixed with acetic acid to form a thin paste. This cement must always be used immediately after being mixed, as it solidifies if allowed to stand for any length of time.—"American Machinist."

Feeder Accident Puts Cleveland in Darkness

A large part of the business section of Cleveland was without electric service for many hours as the result of a mysterious fire in the cable subway and manholes at Ontario St. and Vinegar Hill, a few hundred feet from the Canal Road plant of the Cleveland Illuminating Co. The accident occurred about 2 a.m., Tuesday, Dec. 15, and it was not until Thursday night that full service was restored through the stringing of temporary cables. In the meantime many factories were without power, hotels and office buildings were without elevator service or light, and several thousand people were rendered idle.

The 22 one-million circular-mil and six two-million circular-mil cables, which were put out of service, are carried overhead from the power house, a distance of about 400 ft.; then they descend along a wooden pole to the manhole and subway at Vinegar Hill. The manhole covers were blown off, and when the firemen arrived the interior was like a furnace, several hours elapsing before the fire could be put out completely and the smoke from the burning insulation in the ducts cleared away.

The cause of the accident does not appear to have been determined, although a thorough investigation is being made by the company.

TRADE CATALOGS

The Hayden & Derby Mfg. Co., 119 West 40th St., New York. Catalog D-1. Metropolitan injectors, H-D injectors and jet apparatus. Illustrated, 62 pp., 6x9 in.

The Imperial Brass Mfg. Co., 1200 West Harrison St., Chicago, Ill. Catalog No. 92. Heating specialties for vacuum and graduating systems. Illustrated, 32 pp., 6x9 in.

National Tube Co., Pittsburgh, Penn. Circular. Kewanee union, male and female pattern. Illustrated.

Goldschmidt Thermit Co., 90 West St., New York. Pamphlet. Thermit process of pipe welding. Illustrated, 24 pp., 6x9 in.

NEW PUBLICATIONS

THE ANALYSIS OF COAL WITH PHENOL AS A SOLVENT, by S. W. Parr and H. F. Hadley, has just been issued as Bulletin No. 76 of the Engineering Experiment Station of the University of Illinois.

This bulletin shows that by means of phenol, bituminous coal may be divided into two main portions. A study of each division can therefore be carried on to much better advantage than when in the combined state. In general it has been found that the resinic or pitch-like material is soluble in phenol, that it possesses substantially all of the coke producing ingredients, that oxidation destroys the coking property, that this oxidation occurs slowly at ordinary temperatures and proceeds much more rapidly at 212 deg. F. The insoluble material or cellulose residuum is a more active absorber of oxygen; it has no coking property but resembles the lignitic coals in this respect as also in its avidity for oxygen. It is, therefore, to be considered as the constituent most actively involved in spontaneous combustion, deterioration and other difficulties attending the storage of coal.

Copies of Bulletin No. 76 may be obtained gratis upon application to C. R. Richards, Acting Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

THE ORIGIN OF COAL. By David White and Reinhardt Thiessen, with a chapter on the Formation of Peat by Charles A. Davis. Published by the Bureau of Mines; 390 pages, 54 illustrations; paper: 6x9 in. Bureau of Mines Bulletin No. 38.

The purpose of the investigations recorded in this bulletin was to learn by "microscopic examinations of coals, how far and in what ways the grouping of coal by types depends on differences in the kinds of plant material from which it was formed and on the conditions of its accumulation, or how far the special characters or qualities of coal of any type were determined by the nature and state of the plant débris from which the coal was formed.

The opinion that coal is transformed peat is held by the authors. The report is quite thorough in that coals and peat from the various sections of this country have been critically studied under the microscope.

Under a historical review. Mr. Thiessen considers the more important of the investigators of the compositions of coal. To geologists and related scientific men the book should be of deep interest, but we do not believe engineers will find it of professional value.

TURBINEN MIT DAMPFENTNAHME. A contribution to the study of bleeder turbines, by Dr. August Kriegbaum. Published by R. Oldenburg, Munich and Berlin. 6½x9½ in., 130 pages, 98 illustrations. Paper. Price, 4½ marks.

The author of this book has not attempted to write about steam turbines in general, but has restricted himself to bleeder turbines. This type of turbine is only to be considered in plants where power production and heating are to be combined.

Sizes required, efficiency, steam consumption and many other values depend largely upon the pressure of the steam to be used for heating and the proportion of the quantity of heating steam to the quantity of steam entering into the turbine. These and other points the author examines carefully in the two chapters of this book.

The present types of turbines he divides into two groups, namely, nozzle turbines with few and guide-blade turbines with many stages. In the first chapter, with the use of mathematical formulas and graphical methods, the conditions are laid down for the velocity in the different stages of a Curtis turbine in order to obtain the highest efficiency with relation to the steam pressure which is to be drawn from the turbine for other industrial purposes. By careful investigation it may be determined when and at what point one turbine system is to be preferred to the other in respect to efficiency. Diagrams further explain the influence of the quantity of steam to be drawn upon the output of the turbine, also upon the steam and heat consumption for combined plants, as well as separate power-producing and heating plants.

In the second chapter the behavior of a steam turbine is examined in respect to the usual regulating methods for changing load conditions. These examinations have the further object of determining what conditions are important to economical operation, and are based upon the exact definition of the change of state of the steam when flowing through the turbine. Extensive graphical methods with the help of the Mollier J-S diagram are used.

The author has contributed considerable to the study, design and construction of the bleeder type turbine, so that the book should prove valuable to designers and to students who want to specialize in this type of steam turbine. The fact that the entire work is strictly theoretical will probably keep the practical power-plant man from reading it unless he is interested in this particular subject.

BUSINESS ITEMS

Arthur E. Jackman has been appointed manager of the machinery department of the Walter A. Zelnicker Supply Co., of St. Louis, vice J. J. Hilpirt, resigned to become storekeeper of Cia. Mexicana De Petroleo, "El Aguilla" S. A. at Tampico, Mexico. Mr. Jackman has had wide experience gained as general manager of the Sea View R.R. and Narragansett Pier E. L. & P. Co., was for years in the R. & L. Dept. of the Westinghouse Electric & Manufacturing Co. and latterly superintendent of the East St. Louis, Columbia & Waterloo Ry., which position he left to assume his present duties.

Tripp Metallic Packing, manufactured by Wm. B. Merrill & Co., 3368 Washington St., Jamaica Plain, Boston, Mass., will be supplied for all piston rods and poppet valve stems of the three new pumping engines, now being built for the City of Cleveland. This company is also building metallic packing for 16-in. gas rods and 16-in. air rods of engines now being constructed for the Pennsylvania Steel Company, Steelton, Penn.

The Ohio Blower Co., 5130 Perkins Ave., Cleveland, Ohio, has just issued a handy booklet containing some sheet metal and angle iron suggestion's for factory superintendents, efficiency engineers and contractors. It is called the Handiline Handibook—contains many illustrations—and is sent for the asking.

It having been brought to its attention that rumors were being circulated that it intended to retire from the piping business, the Best Manufacturing Co., of Pittsburgh, Penn., wishes to emphatically deny these rumors and assures the trade that it is now and intends to continue aggressively prosecuting the piping business.

Benjamin G. Fernald has resigned as sales manager of the Best Manufacturing Co., Pittsburgh, Penn., in order to enter business in New York City about the first of January.

A. E. Seelig has been appointed general sales manager of the Kerr Turbine Co., Wellsville, N. Y., and John A. Hense, St. Louis representative. Mr. Seelig for several years held a similar position with the L. J. Wing Manufacturing Co., and more recently managed the new machine tool department in the New York office of Schuchardt & Schutte. Mr. Hense was formerly with the National Malleable Castings Co., Chicago, and later with the Dravo-Doyle Co., of Philadelphia.

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